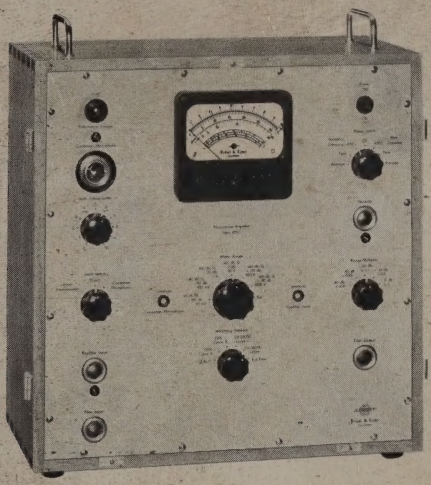
2603

INSTRUCTIONS AND APPLICATIONS

Microphone Amplifier Type 2603



The instrument is designed for the amplification and measurement of small a.c. voltages. The total amplification is 100 db. By means of a switch the built-in rectifier and meter circuit can be switched to measure either the arithmetic average, the true R.M.S. or the peak value of the input signal. The instrument also contains the internationally standardized weighting networks for sound level measurements. Connections for Condenser Microphone and Level Recorder.

- Acoustic standing wave apparatus
- Artificial ears
- Artificial voices
- Audio frequency spectrometers
- Audio frequency voltmeters
- Automatic A. F. spectrum recorders
- Automatic frequency response recorders
- Beat frequency oscillators
- Condenser microphones
- Deviation bridges
- Distortion measuring bridges
- Electronic counters
- Frequency analyzers
- Frequency measuring bridges
- Frequency response tracers
- Hearing aid test apparatus
- Heterodyne voltmeters
- Level recorders
- Megohmmeters
- Microphone amplifiers
- Microphone calibration apparatus
- Noise sources
- Polar diagram recorders
- Preamplifiers
- Recording paper
- Rotary selectors
- Strain gauge apparatus and accessories
- Surface roughness meters
- Vibration pick-ups
- Wide range vacuum tube voltmeters

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Microphone Amplifier

Type 2603

Reprint: May 1960

Contents.

Page

Description 3
- General 3
- Description of the Amplifier Section 4
- Description of the Power Supply 7

Operation 9
- General 9
- Voltage Measurements 9
- Use of Type 2603 as Sound Level Meter 9
- Recording of the Sound Level as a Function of Time 12

Auxiliary Equipment 14
- Use of External Filters 14
- The Two Channel Microphone Selector Type 4408 15

Applications 16
- Distortion Measurements 16
- Microphone Amplifier 2603 as Bridge Indicator 17
- Vibration Measurements 18
- Recording of Motor Noise and Vibrations 20
- Automatic Recording of Airborne Sound Insulation 21
- Measurement of Acaustic Absorption Coefficients 23
- Microphone Amplifier 2603 used as Compressor-Amplifier 24
- A. Checking of Hearing Aids 25
- B. Measurements at High Sound Pressure Level 27
- C. Measurements of Mechanical Strain in Objects subjected to Vibrations 28
- D Measurements of Microphony in Tubes 29

Appendix 32
- A. Some Notes on the Arithmetic Average, R.M.S. and Peak Value .. 32
- B. Weighting Networks for Sound Level Measurements 33

Specification 36

Description.

General.

The Microphone Amplifier Type 2603 is primarily designed for acoustical, electro-acoustical and vibration measurements.

It consists basically of two independent amplifier sections which may either be connected directly in cascade or have a filter system interposed between them. The power supply contains the necessary rectifiers and filters for operating these amplifiers as well as for operating a B & K Condenser Microphone or Preamplifier.

The input- and output amplifier sections can, as mentioned above, be cascaded by means of a switch on the front panel. Thereby a high gain

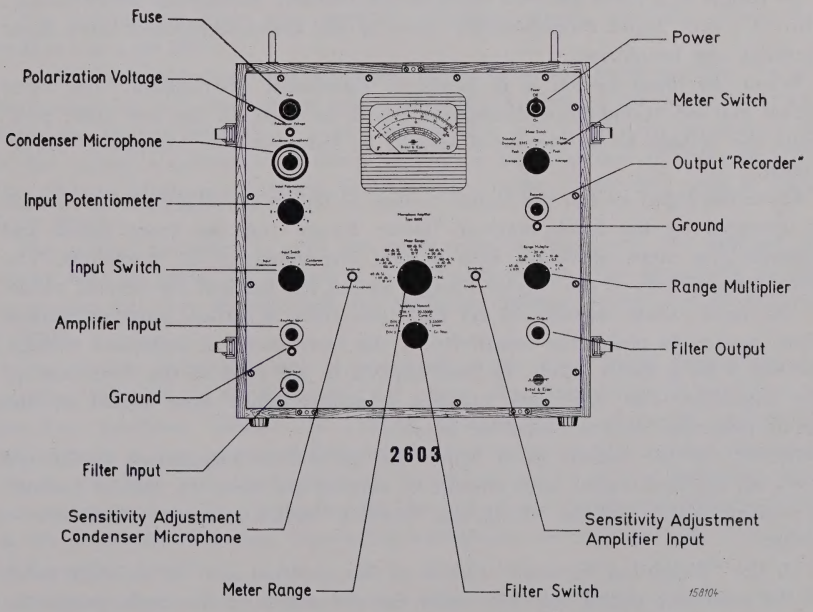

Fig. 1. Drawing of Type 2603 with control knob identification.

ampifier with a linear frequency characteristic in the range from 2 c/s—35 kc/s is obtained. The switch also enables a series of built-in weighting networks corresponding to DIN 5045, and ASA Z 24.3 to be inserted between the amplifier sections, or the amplifier sections to be isolated from each other and connected to terminals provided for external filters.

When using the built-in weighting networks it will, in connection with one of the B & K Condenser Microphones, conform with the specifications for a standard sound level meter.

If frequency analysis is required, external filters, such as the 1/3 Octave Filter Set Type 1610 can be inserted between the amplifier sections. The set-up will then be identical to the Audio Frequency Spectrometer Type 2110.

For vibration measurements the Preamplifier Type 1606 or Cathode Follower 2612 or 2613 with Accelerometers Type 4308 or 4309 should be connected to the "Condenser Microphone" input of the Amplifier.

Description of the Amplifier Sections.

The input amplifier section consists of three stages and is provided with two different input sockets, one of which is seven poled and corresponds to the plug on the B & K Condenser Microphones and Preamplifiers. The other input socket accommodates a 14 mm coaxial plug and can be connected to the input circuit of the amplifier, either directly, or via a variable potentiometer used for relative measurements.

By means of a three-position input switch marked "Condenser Microphone", "Direct", and "Input Potentiometer", one of the above-mentioned three input facilities can be chosen.

When the input switch is in position "Condenser Microphone" the input socket marked "Condenser Microphone" is to be used. In the two other positions the voltage to be measured should be fed onto the "Amplifier Input" socket.

From the input switch the signal voltage is fed to a voltage divider, which is operated by the knob marked "Meter Range" on the front panel and contains five steps of 20 db with a total impedance of 2.2 megohms. The different positions of the "Meter Range" switch are marked for several values of the input voltage between 10 mV and 1ooo volts. A further position marked "Ref." serves to check the sensitivity of the instrument. A stabilized voltage, derived from a Zener diode, is then applied to the grid of the first tube of the amplifier. The reference supplies a square wave type signal of the mains frequency to the Amplifier input.

However, for the reason given below the calibration adjustment to the red mark on the instrument scale should be carried out with the "Meter Switch" in position R.M.S. and the "Weighting Network" switch set to "2—35ooo c/s — Linear".

With the "Weighting Network" switch in this position also the average value of the reference signal coincides with the red mark on the scale, while the peak value will be indicated by a o.5—1 db greater deflection.

With the "Weighting Network" switch in position "20—35000 c/s — "Curve C" the R.M.S. calibration will still show a correct value.

The average and peak value, however, will now deviate from this value. A deviation of up to 4 db may be expected when the "Meter Switch" is switched to "Peak".

The deviation between the peak — average — and R.M.S. value here described are mainly caused by phase distortion in the amplifier, which will be noticeable on peak measurements of complex signals just above the lower limiting frequency.

The frequency af the reference signal is 50 c/s, and the voltage will vary less than 0.3 % for a 10 % variation in the mains.

The two first stages of the amplifier consist of resistance-capacitance coupled triodes, while the third stage is built as a cathode-follower. A great amount of negative feedback is introduced to stabilize the amplifier and ensure a low source impedance, approx. 12 Ω, at the "Filter Input" terminal.

The heaters of the amplifier tubes are supplied from a bridge rectifier. In this way a hum level lower than two microvolts, referred to the grid of the input tube, has been achieved.

As the tubes and the corresponding coupling components are mounted on a rubber-suspended chassis there is no disturbance from microphony in the amplifier, even when a signal of only a few microvolts is being measured.

The output amplifier also consists of three stages, and the input impedance is 1.45 MΩ.

In the input circuit a voltage divider, operated by the knob marked "Range Multiplier" on the front panel and containing 4 steps of 10 db, is inserted. With the "Range Multiplier" switch in position $\times$ 1 (0 db) the amplification of the output amplifier is 10 times. Maximum amplification is obtained with the "Range Multiplier" switch in position $\times$ 0.01 (—40 db), and is then 1000 times.

The output amplifier is provided with negative feed-back, the amount of which may be varied by means of two potentiometers. The sensitivity of the apparatus can thus be adjusted, the reference voltage being used as control voltage.

One of the potentiometers is in circuit when the "Input Switch" is in position "Condenser Microphone", the other when the switch is in either of the two positions "Direct" or "Input Potentiometer". Separate sensitivity adjustment is thus obtained for sound measurements and voltage measurements, which is very convenient for the practical use of the Amplifier. The potentiometers can be operated with the aid of a screwdriver through holes in the front panel marked "Sensitivity-Condenser Microphone" and "Sensitivity-Amplifier Input".

The output circuit of the amplifier is connected both to the output terminals marked "Recorder" and to the rectifier and meter circuit.

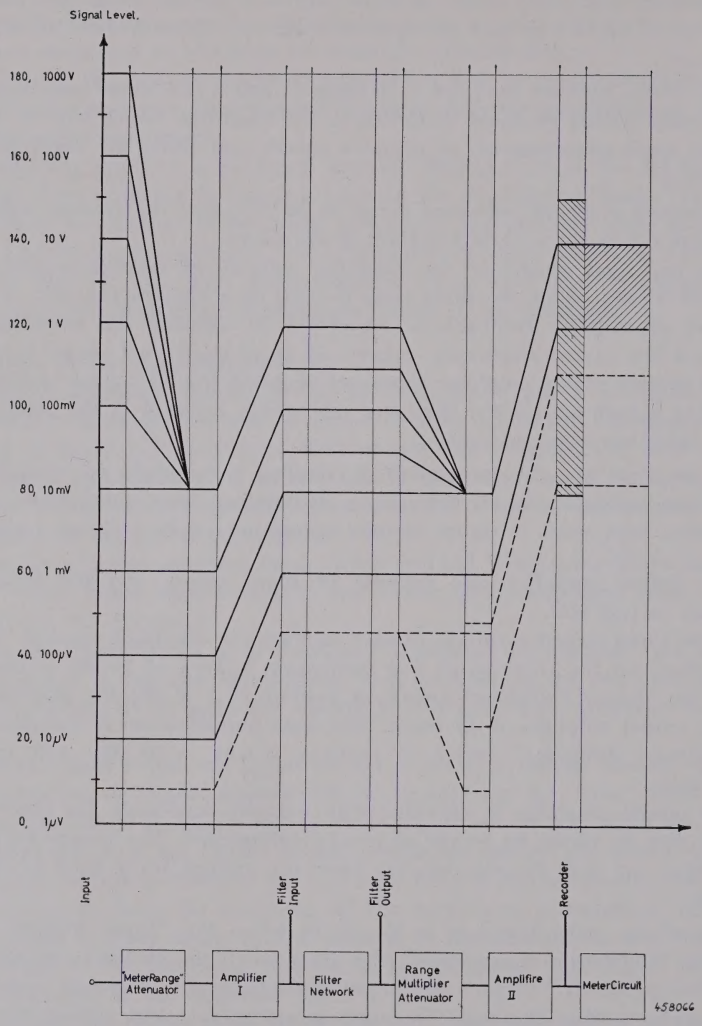

Fig. 2. Sketch showing the signal levels, at different points in the Microphone Amplifier. The dotted lines indicated the noise levels.

The "Recorder" terminals are provided for connection to headphones, oscillograph or level recorder, etc. or it can be connected to the compressor input of the Beat Frequency Oscillator Type 1014 or 1015. The output impedance is smaller than 50 ohms, and a maximum voltage of approx. 30 volts r.m.s. is available.

A switch in the rectifier circuit enables either the peak, the arithmetic average or the true r.m.s. value of the input signal to be measured. Furthermore, two different damping characteristics of the meter can be selected, one of which is in accordance with the standards for sound level measurements. Because this damping characteristic will cause the meter pointer to "vibrate" at frequencies lower than 10 c/s, a greater damping can be chosen for the measurements of very low frequency signals.

The r.m.s. rectifier circuit is designed to approximate the square-law curve by means of straight line portions. The resulting curve enables the true r.m.s. value of signals with crest factors up to 5 to be measured to within $\pm$ 0.5 db of the theoretically correct value.

The peak rectifier circuit is designed to measure half the peak-to-peak value of the input signal. This should be borne in mind when peak measurements are carried out on unsymmetrically shaped signals.

When the instrument meter gives full scale deflection, a voltage of 10 volts is available across the "Recorder" terminals.

The meter itself is gradated 0—10 and 0—31.5 as well as 0 to 20 db. Furthermore, scales permitting the direct reading of acoustic absorption coefficients are provided. These scales should be used when measurements are taken with the Standing Wave Apparatus Type 4002.

When the "Range Multiplier" switch is in position $\times$ 1 (0 db) the signal to noise ratio for full scale deflection on the meter is better than 60 db for any setting of the "Meter Range" switch, see Fig. 2.

By using any of the other four positions of the "Range Multiplier" switch the signal to noise ratio for full meter deflection decreases the same number of db as the amplification is increased.

To obtain the best ratio between signal- and noise-voltage, the "Range Multiplier" switch should therefore, during measurements, be set to give as low amplification of the output amplifier as possible, preferably $\times$ 1 (0 db). However, when measurements are carried out where filters are inserted between the two amplifier sections care must be taken not to overload the input amplifier section.

The "Filter Switch" should therefore in this case first be set to position "2—35000 c/s Linear" and the amplification of the instrument be adjusted as described above. This is necessary to make sure that no large voltage components exist outside the band limits of the filters. When the filters are inserted such voltage peaks will not be detectable on the meter and might therefore easily overload the input amplifier. If even weak components of a frequency spectrum have to be measured, the amplification should, for the

reason given above, be increased by means of the "Range Multiplier" switch until a suitable deflection is obtained on the meter.

When Type 2603 is used in connection with the ⅓ Octave Filter Set Type 1610 this combination is equivalent to an Audio Frequency Spectrometer of the Type 2110, and reference should then be made to the instruction manual for this instrument (Type 2110).

The input signal voltage which gives full deflection on the meter is found by multiplying the number of mV indicated on the chosen position of the "Meter Range" switch by the multiplication factor indicated on the position of the "Range Multiplier" switch. If, for example, the "Meter Range" switch is in position 1 V (100 db) and the "Range Multiplier" switch is in position $\times$ 1 (0 db) full deflection on the meter occurs for 1 volt $\times$ 1 = 1 volt.

Using the full amplification of the apparatus full deflection on the meter corresponds to an input signal voltage of 10 mV $\times$ 0.01 = 100 μV.

Description of the Power Supply.

The power supply section of the apparatus contains three rectifiers, one of which supplies the heater current to the apparatus itself. Another supplies heater current to the amplifier tubes of one of the B & K Condenser Microphones or Preamplifiers via the "Condenser Microphone" input socket, and a third one supplies the necessary anode voltages for the amplifiers as well as the polarization voltage for the microphone cartridge of the Condenser Microphones. The anode voltage is stabilized with the aid of two neon tubes. A bushing marked "Polarization Voltage" on the front panel of the apparatus makes it possible to measure quickly the polarization voltage for the microphone cartridges by means of an ordinary sensitive voltmeter (current consumption not more than 50 μA).

The voltage can be adjusted by means of a screwdriver operated potentiometer on the back of the instrument. The adjustment range is 150 to 250 volts. Before the instrument leaves the factory the voltage is adjusted to 200 volts.

The apparatus should be operated from a 50 to 400 c/s power line and can be adjusted for mains voltages of 115—127—150—220 or 240 volts. The power consumption is approx. 50 watts. Adjustment for the different supply voltages can be carried out with the aid of a screwdriver through a hole in the back plate of the apparatus. A printed dial mounted on the adjuster shows the value of the supply voltage to which the apparatus is set. The primary side of the power transformer is fused, the fuse being placed in a fuse-holder on the front panel of the apparatus.

If the apparatus is to be operated from an accumulator, or from other DC supplies, the use of a vibrator or a rotary converter is necessary.

Operation.

General.

Make sure that the instrument is adjusted to the appropriate power supply voltage. It can then be switched on with the aid of the switch marked "Power" on the front panel. The light on the meter scales comes on immediately, and after a warming-up time of about two minutes the apparatus is ready for use.

The sensitivity of the amplifier is checked by means of the reference voltage, the "Filter Switch" being set to position "2—35000 c/s Linear" or "20—35000 Curve C"), "Input Switch" to "Direct", "Meter Range" to "Ref.", "Range Multiplier to × 1 (0 db), and the meter switch to "Standard Damping, RMS".

After 20—30 seconds the current regulator tube will be in a stable condition and the meter should now show a deflection to the red mark on the scale. Possible deviations should be corrected by means of the potentiometer marked "Sensitivity-Amplifier Input" on the front panel, which has to be operated by a screwdriver.

Voltage Measurements.

The apparatus might be used as a linear tube voltmeter in the *audio* frequency range with a maximum full scale deflection sensitivity of 100 microvolts. The voltage to be measured is fed to the »Amplifier Input" input socket and the input switch is set to position "Direct". The input resistance is then 2.2 megohms and the input capacity approx. 30 $\mu\mu$F. The "Filter Switch" is set to "2—35000 c/s Linear", and the desired voltage range chosen by means of the "Meter Range" and "Range Multiplier" switches. If possible, the "Range Multiplier" switch should be in position × 1 (0 db), the reason for this being given under "Description of the Amplifier Sections".

If desired, the voltage measured can be recorded on a level recorder, for example Type 2304, which should then be connected to the output socket marked "Recorder".

Use of Type 2603 as Sound Level Meter.

One of the most important applications of the Microphone Amplifier Type 2603 is its use as Sound Level Meter in combination with one of the B & K Condenser Microphones.

The Microphone can be connected to the input socket marked "Condenser Microphone" on the front panel of the Amplifier, either by inserting the

Microphone's seven-poled plug directly in the socket, by using the Extension Rod UA 4115 or by means of an Extension Cable, see also Fig. 3. If the Microphone is connected to the Amplifier by means of an Extension Cable it is normally advantageous to place it in one of the Microphone Stands UA 0026 or UA 4122.

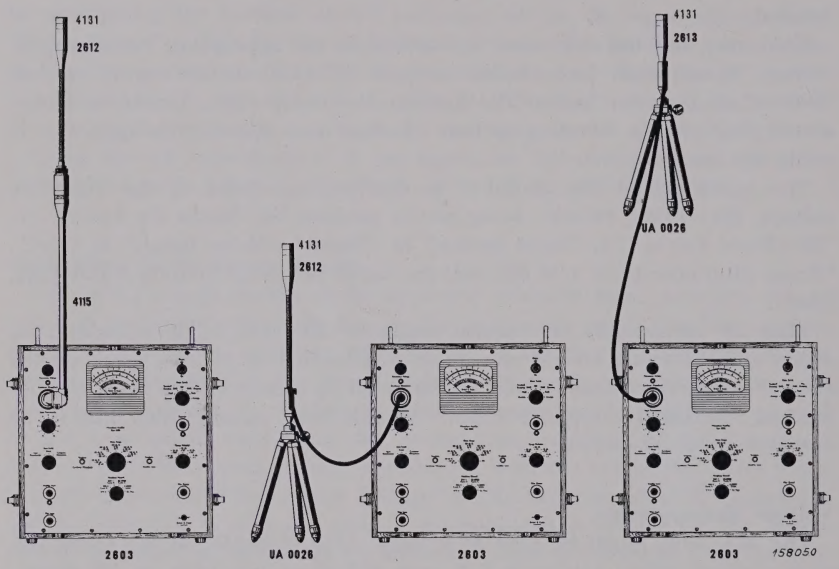

Fig. 3. Different methods of connecting the Condenser Microphone to the Amplifier.

The combination Microphone Amplifier + Condenser Microphone may then be calibrated in the following way:

1. The "Input Potentiometer" knob on the Amplifier front panel can be in any position.
2. Set "Input Switch" to "Condenser Microphone".
3. "Meter Range": "Ref.".
4. "Filter Switch": "20—35000 c/s (Curve C)".
5. "Power": "On".
6. Meter Switch: "Standard Damping RMS".
7. "Range Multiplier": "× 1 (0 db)".
8. Allow two minutes warm-up time.
9. From the calibration curve of the Microphone employed a correction factor "K" in db is found, see also Fig. 4.

10. Turn the "Sensitivity-Condenser Microphone" potentiometer until the meter pointer deflects to the red mark + K*) db on the meter db scale. The actual sound level can now be measured:

11. Expose the Condenser Microphone to the sound field, and turn the "Meter Range" switch counter clockwise until a suitable deflection is obtained on the instrument meter. If a convenient deflection on the meter cannot be obtained by using the "Meter Range" switch only, the "Range Multiplier" switch may be set to position "× o.3 (—10 db)".

12. Measure first the actual *sound pressure level:***)*

    S.P.L. = *Meter deflection in db + Setting of "Meter Range" switch in db S.L. + Setting of "Range Multiplier" switch in db.*

    The result of this addition is the sound pressure level in db re. 2×10^{-4} μbar.

13. If the S.P.L. found in this way is higher than 130 db (re 2×10^{-4} μbar) this is also the actual *sound level.****) If not proceed as follows:

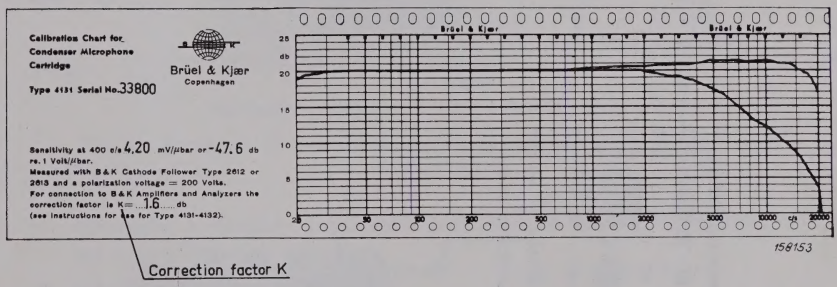

Fig. 4. Typical Microphone calibration curve with indication of the factor "K" in db.

14. Set the "Filter Switch" to "DIN 1 (Curve B)", and find the sound level as described under item 12. If the sound level is higher than 60 db (re 2×10^{-4} μbar) no further measurement is necessary, the value found being the actual sound level. If not:

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*) The db S.L. calibration on the B & K amplifiers (or analyzers) is referred to a microphone sensitivity of exactly 5 mV/μbar, and the correction factor K indicates how many db its sensitivity deviates from this value. The factor therefore correlates the db S.L. (db sound level) scale on the B & K Microphone Amplifiers and Analyzers with the sensitivity of the microphone actually in use.

) The **sound pressure level is found from measurements using linear frequency characteristic for the measuring equipment.

***) The **sound level** is found from measurements using the correct weighting network, see also Appendix B, p. 33.

15. Set the "Filter Switch" to "DIN 2 (Curve A)", and find, once again, the sound level. If the sound level found from the addition is lower than 30 db (re 2×10^{-4} μbar) still one further measurement is necessary:

16. Set the "Filter Switch" to "DIN 3" and find the sound level. For further explanation of these measurements see, if desired, "Appendix - B. Weighting Networks for Sound Level Measurements".

Recording of the Sound Level as a Function of Time.

In many workshops and offices the noise level varies considerably with time and if the noise level is measured in such places by means of a single reading, a serious error might be introduced. In such cases it is necessary to record the noise level over a relatively long period of time. A satisfactory average figure can then be obtained and noise peaks be observed, which are of particular interest from a health point of view.

A suitable measuring arrangement for sound level recordings is shown in Fig. 5, and consists of one of the B & K Condenser Microphones, the Microphone Amplifier Type 2603 and the High Speed Level Recorder Type 2304.

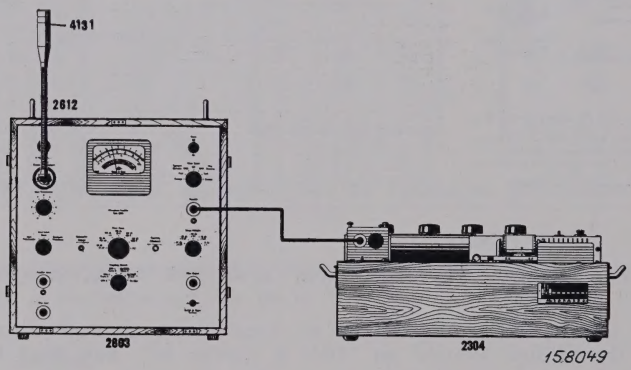


Fig. 5. Measuring set-up for recording the sound level as a function of time.

The operation procedure is as follows:

1. Measure the sound level according to the preceding chapter "Use of Type 2603 as Sound Level Meter".
2. Supply the Level Recorder with a 50 db Potentiometer and recording paper QP 2350 (for ink writing) or QP 2351 or QP 2352 (writing by means of sapphire stylus), and set the knobs of the Recorder, Fig. 6, as stated below:
3. "Zero Level Adjustment": Fully counter clockwise.

4. "Lower Limiting Frequency": "20 c/s".
5. "Potentiometer db Range": "50".
6. "Writing Speed": "140".
7. "Motor": "Off".
8. "Amplifier": "On".
9. "Slider": "Record".
10. Turn the Level Recorder "Input Potentiometer Knob" until a suitable deflection of the recorder stylus is obtained on the paper.

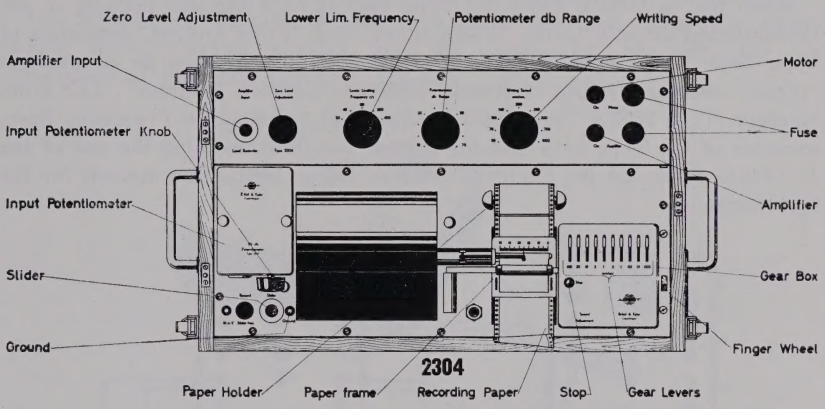


Fig. 6. Drawing of the Level Recorder Type 2304 for control knob identification.

11. Determine a suitable paper speed and engage the corresponding lever of the Level Recorder Gearbox.
12. Set the "Motor" switch to "On".

When the desired period of time for the recording has passed the Level Recorder motor is stopped and the paper cut off.

Remarks: For calibration of the recording paper use the sound level measured during adjustment.

In case the sound level measured varies too quickly to obtain a proper "calibration" of the measuring set-up it is recommended to use the Noise Source Type 4240.

Auxiliary Equipment

Use of External Filters.

As mentioned under "Description" external filters may be inserted between the input and output amplifier sections of the Microphone Amplifier.

When the ⅓ Octave Filter Set Type 1610 is used for this purpose it can be connected directly to the "Filter Input" and "Filter Output" terminals of Type 2603. The "Input Switch" of Type 1610 should then be in position "Direct" and the "Output Matching" switch in position "Internal". This combination (Type 2603 + Type 1610) is equivalent to an Audio Frequency Spectrometer of the Type 2110 and for further details concerning the use of the ⅓ Octave Filter Set the reader is referred to the instruction manual for the Spectrometer.

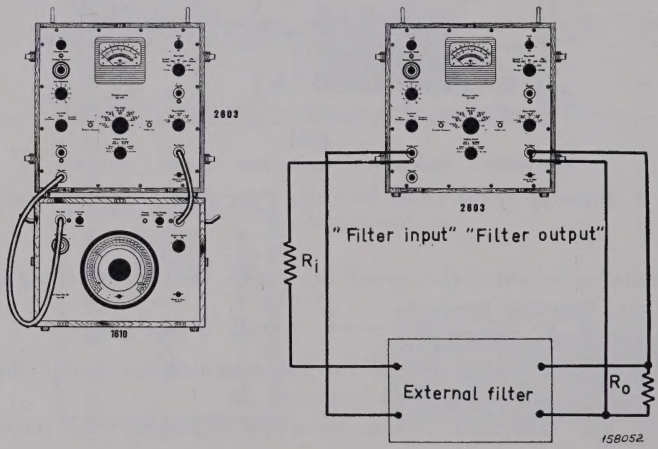


Fig. 7. Use of external filters in connection with the Microphone Amplifier Type 2603.

If other filters than Type 1610 are used in connection with the Microphone Amplifier care should be taken as to the proper matching of the filters. The output impedance of the input amplifier section of Type 2603 is approx. 12 ohms, and in most cases a series resistor must therefore be added to match the filter, see also Fig. 7. The input impedance of the output amplifier section is 1.46 Mohms, and it might therefore be necessary to parallel the filter output by a suitable resistor.

Note: The max. (open circuit) A.F. voltage available from the input

amplifier section of Type 2603 is approx. 20 volt. The DC voltage across the "Filter Input" terminals is approx. 75 volts.

The Two Channel Microphone Selector Type 4408.

This apparatus is designed as an accessory to the Analyzers and Microphone Amplifiers produced by Brüel & Kjær and enables the output from one or the other of two of the B & K Condenser Microphones to be automatically or manually switched into a single amplifier.

A recording of two phenomena, e.g. the sound pressure of two different points in a sound field, can thus be obtained on a Level Recorder.

The Microphone Selector is built in a metal box and contains a toggle switch which operates a relay, and the components necessary for the elimination of hum and crosstalk effects.

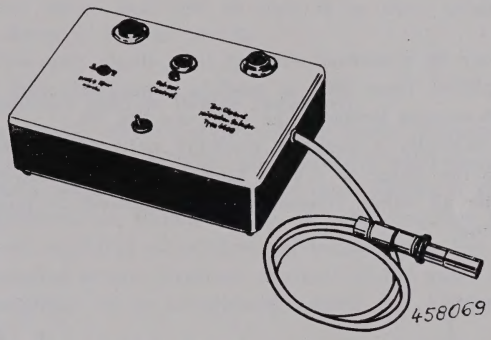


Fig. 8. The Two Channel Microphone Selector Type 4408.

When the Selector is operated manually the toggle switch is employed. The switch then operates the relay, which in turn switches the output from Type 4408 to one or the other of its two inputs.

The Selector may also be remote controlled. The toggle switch must then be in position "2", and the external control switch by means of a cable connected to the terminals marked "External Control", whereby the external switch replaces the function of the toggle switch.

Some technical data:

The Two Channel Microphone Selector is designed for use with the B & K Condenser Michrophones.

The cross-talk effect is negligible. Due to coupling in the H.T.-supply (between the two anodes) the effect of crosstalk is greatest at lower frequencies, but is reduced by more than 80 db at 20 c/s.

Transients in the switching-over from one input to the other may last for approx. 100 msec.

NB! Due to the series heating of the tubes the Type 4408 can only be used when both Microphones are connected.

A drawing of Type 4408 is shown in Fig. 8.

Applications.

Distortion Measurements.

The non-linear distortion in four-terminal networks is normally expressed by means of the formula:

$$d = 100 \sqrt{\frac{A_2^2 + A_3^2 + A_4^2 + \ldots}{A_1^2 + A_2^2 + A_3^2 + \ldots}} \approx 100 \frac{\sqrt{A_2^2 + A^2_3 + A^2_4 + \ldots}}{A_1} \%$$

The factor d can be measured directly in a single measurement when the Microphone Amplifier Type 2603 is used in connection with the Frequency and Distortion Measuring Bridge Type 1602, see Fig. 9a.

Type 1602 is basically a variable blocking network, by means of which any frequency in the range 47 c/s to 12000 c/s can be attenuated by more than 80 db while all other frequencies are allowed to pass the network without attenuation.

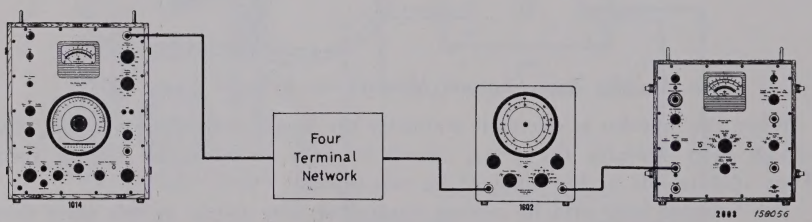


Fig. 9a. Measuring arrangement suitable for distortion measurements.

To measure the factor d the complete signal should first be fed to Type 2603, and the meter pointer of the instrument adjusted to give max. deflection. The measuring frequency is then blocked out by means of Type 1602, and the reading on the Amplifier meter is now the factor d %. *Note:* The Microphone Amplifier must be switched to measure the R.M.S. value of the signal.

In the above mentioned measuring set-up the Beat Frequency Oscillator Type 1014 is used as signal source. The Oscillator itself has a distortion factor of 0.25 % at 1000 c/s when loaded with 1 watt, and will thus be well suited for normal distortion measurements where the factor d of the network being tested is greater than 3 %. However, in high fidelity audio frequency amplifiers, and other equipment with extreme low distortion the

measuring arrangement shown in Fig. 9a should be substituted with the one shown in Fig. 9b.

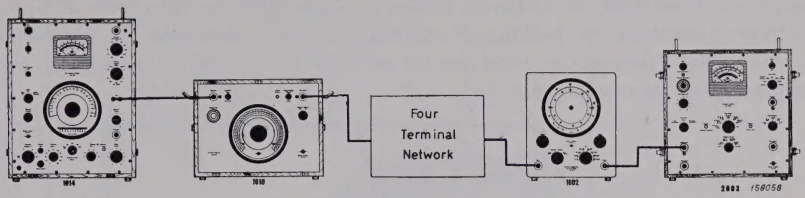


Fig. 9b. Measuring set-up for measurements on networks with extremely small harmonic distortion.

The Filter Set Type 1610 will attenuate the harmonics of the Oscillator output signal by more than 50 db and it is then possible to measure harmonic distortions as low as 10^{-2} %.

Microphone Amplifier 2603 as Bridge Indicator.

When making bridge measurements in the audio frequency range it is a great advantage to have a reliable and sensitive instrument in the bridge network. The only requirement the bridge must satisfy is that one diagonal point can be grounded as shown in Fig. 10. This requires the bridge to be supplied from an oscillator via a screened transformer, the signal generator often being grounded at one terminal. Because of the great sensitivity of the Microphone Amplifier it is excellently suited for bridge measurements.

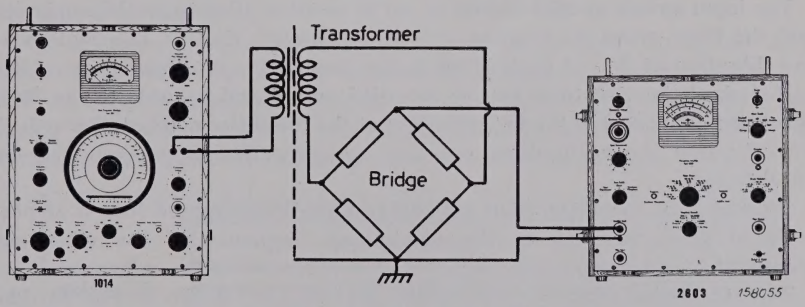


Fig. 10. Amplifier Type 2603 used as bridge indicator.

Furthermore, if the quality of different components placed in the birdge is to be measured the decibel scale on the instrument meter is useful.
As previously mentioned voltage measurements should be carried out with the filter switch in position "2—35000 Linear". The signal voltage can then be read directly off the instrument's volts-scale, full deflection of the meter being indicated by the positions of the "Meter Range" switch and the "Range Multiplier" switch. The instrument is completely protected against overloading.

Vibration Measurements.

Using Accelerometer Type 4308 or 4309 and the Vibration Pick-up Preamplifier Type 1606 or Cathode Follower Type 2612 or 2613 with Adaptor JJ 2612 vibrations in buildings, machinery, ships, etc. can be measured directly. The Preamplifier 1606 can be switched for acceleration, velocity and displacement measurement.

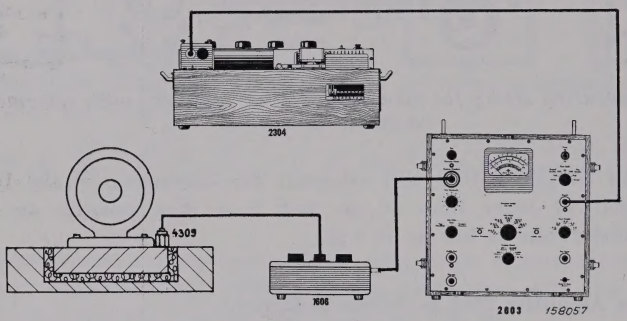


Fig. 11. Set-up for Vibration measurements on a motor's base.

A set-up for vibration measurements on a motor's base is shown in Fig. 11. The voltage from the Accelerometer is fed to the "Condenser Microphone" input socket of the Microphone Amplifier 2603, via a Preamplifier 1606. As previously mentioned the necessary supply voltages for the Preamplifier are supplied from the Microphone Amplifier.

The input switch of 2603 should be set to position "Condenser Microphone" and the filter switch to position "2—35000 Linear". Further information as to calibration of the set-up is given in the manual for the Preamplifier 1606.

If desired the vibrations can be recorded on a Level Recorder Type 2304, this being connected to the output socket of the Amplifier marked "Recorder". An indication of the vibrations over any desired period of time can thereby be obtained.

By means of the integration networks of the Preamplifier 1606 it is possible to get some idea of the dominating frequency of the vibrations measured.

The attenuation characteristics of the networks are shown in Fig. 12. The curves marked V_1 and V_2 refer to the filters used for velocity measurements, while the curves marked D_1, D_2 and D_3 are valid for the filters used for displacement measurements.

If, for example, the dominating frequency of the vibrations is 1000 c/s the recorded level with the filter corresponding to curve D_3 switched in, will be approx. 33 db lower than the level recorded without insertion of the filter (i. e. with the switch marked "Sensitivity per Volt" on the top panel of the Preamplifier in position "Acceleration").

With a vibration frequency of 100 c/s the level difference between a direct

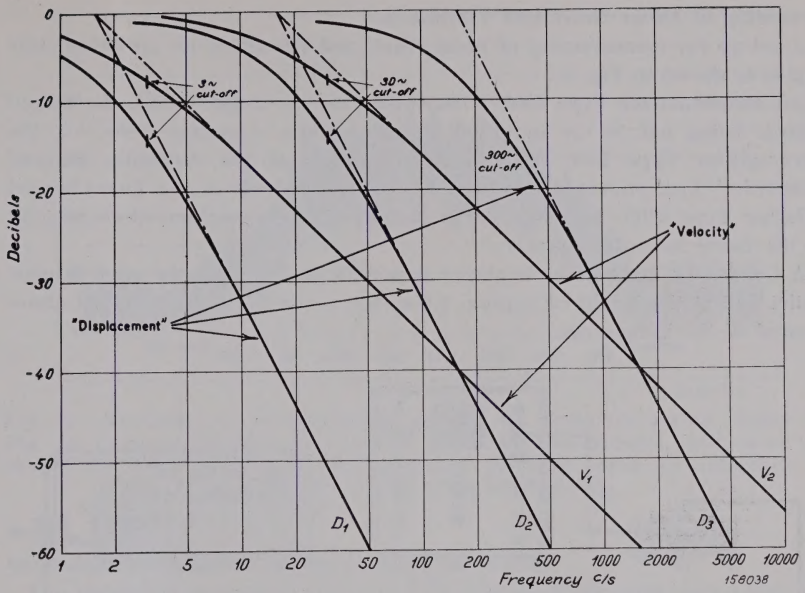


Fig. 12. Attenuation characteristics of the integration networks in Preamplifier 1606.

acceleration measurement, and a measurement with the filter corresponding to curve D_3, is approx. 5 db. Insertion of the next filter (curve D_2) reduces the level a further 28 db.

Fig. 13 shows a recording obtained from measurements carried out on a system as shown in Fig. 11. The dominating frequency is here approx. 50 c/s but some higher frequencies are also present. This might be seen by comparing the levels recorded for the various D-characteristics with the level of the acceleration itself, and by employing the curves of Fig. 12.

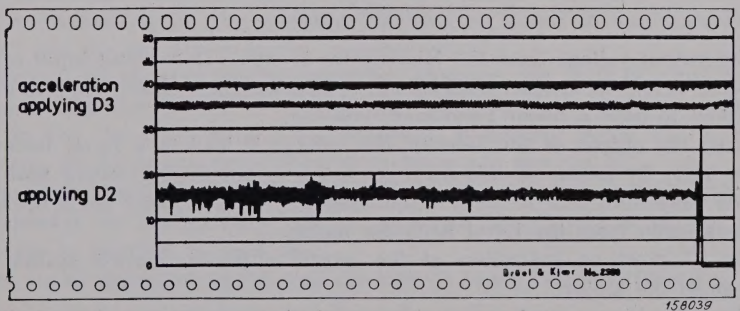


Fig. 13. Recording of measurements carried out by means of the set-up shown in Fig. 11, the integration networks of Preamplifier 1606 being employed to determine the dominating frequency of the vibrations.

Recording of Motor Noise and Vibrations.

A set-up for measurement of noise from, and vibrations of, an automobile engine is shown in Fig. 14.

An Accelerometer Type 4308 is screwed onto the engine itself, the output voltage being fed to the input of the Microphone Amplifier 2603, via the Preamplifier Type 1606. The output terminals of the Amplifier marked "Recorder" are connected to one of the input terminals of the Two Channel Selector Type 4405. This Selector is made for direct mechanical connection to the Level Recorder's motor.

A Condenser Microphone is placed approx. 2 meters from the car's exhaust outlet and at the height of approx. 1.7 meter, i.e. at the average height above ground of the human ear.

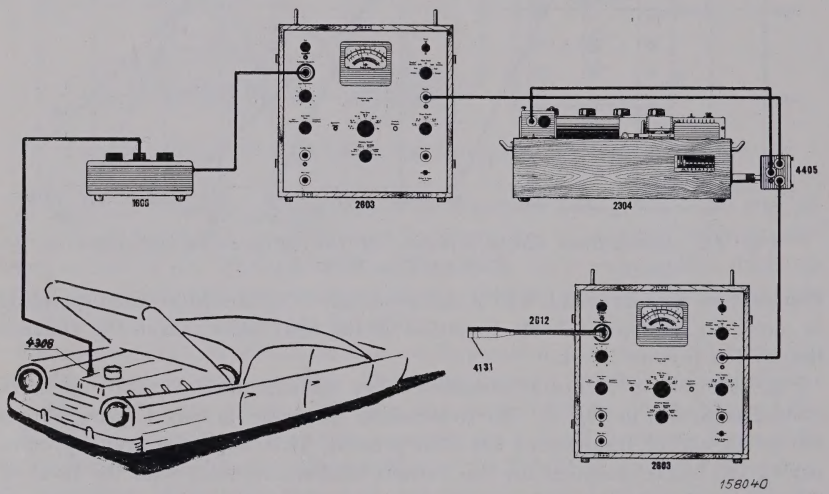


Fig. 14. Set-up for the measurement of noise from, and vibrations of, an automobile engine.

The output voltage from the Microphone is fed to the second input of the Selector 4405, via another Microphone Amplifier 2603. Both Amplifiers are switched to have a linear frequency response.

From the output of the Selector the voltage is lead to a Level Recorder Type 2304. By means of this arrangement it is possible to record both the engine vibrations, and the noise "simultaneously", the Selector being operated automatically from the Level Recorder motor.

Fig. 15 gives an indication of the results obtained, plotted against the r. p. m. of the motor.

The noise is measured as sound pressure (linear frequency characteristic), the vibrations by means of the acceleration. Zero db reference is 1 μbar and 100 cm/sec^2 respectively.

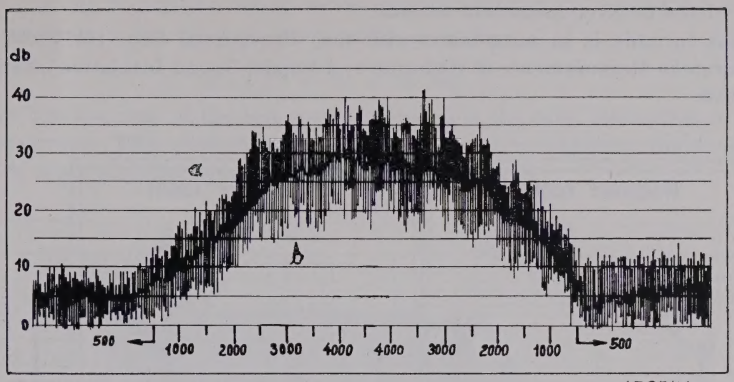


Fig. 15. Recording of measurements carried out using the set-up shown in Fig. 14. Curve a) indicates the engine vibration accelerations, and curve b) shows the noise level measured as sound pressure. Zero db reference is 100 cm sec² and 1 μbar, respectively.

Automatic Recording of Airborne Sound Insulation.

The insulation properties of a wall with respect to airborne sound may be measured as shown in Fig. 16.

The wall separates two rooms, one of which is used as "transmitter room", and the other as "receiver room".

With a measuring arrangement as shown only one Microphone Amplifier Type 2603 is needed, and the measuring results are automatically recorded by the Level Recorder in the Automatic Frequency Response Recorder Type 3302.

The use of only one Amplifier 2603 is made possibly by employing the Two Channel Microphone Selector, Type 4408, which is controlled remotely with a Selector Type 4405. The input to the Microphone Amplifier is thus connected alternatively to the Condenser Microphone, placed in the "transmitter room" and the one placed in the "receiver room".

Because of the mechanical coupling between the B. F. O., the Level Recorder and the Selector 4405, both the sound levels in the "transmitter" and in the "receiver room" are recorded alternately when the B. F. O traverses the frequency range from 20 to 20ooo c/s. See Fig. 17.

The Beat Frequency Oscillator should be frequency modulated and the loudspeaker (or loudspeakers) placed so that a sound field, as diffuse and isotropic as possible, is built up.

The sound insulation of the wall can now be found from the formula:

$$D_{eff} = L_1 - L_2 + X$$

where $L_1 - L_2$ is the sound level difference between the two rooms, obtained frem the recording, and X is a correction factor which takes the sound absorp-

tion of the receiver room into account.

This formula is in accordance with the "Provisional Code for Field and Laboratory Measurements of Airborne and Impact Sound Insulation", ratified in 1950.

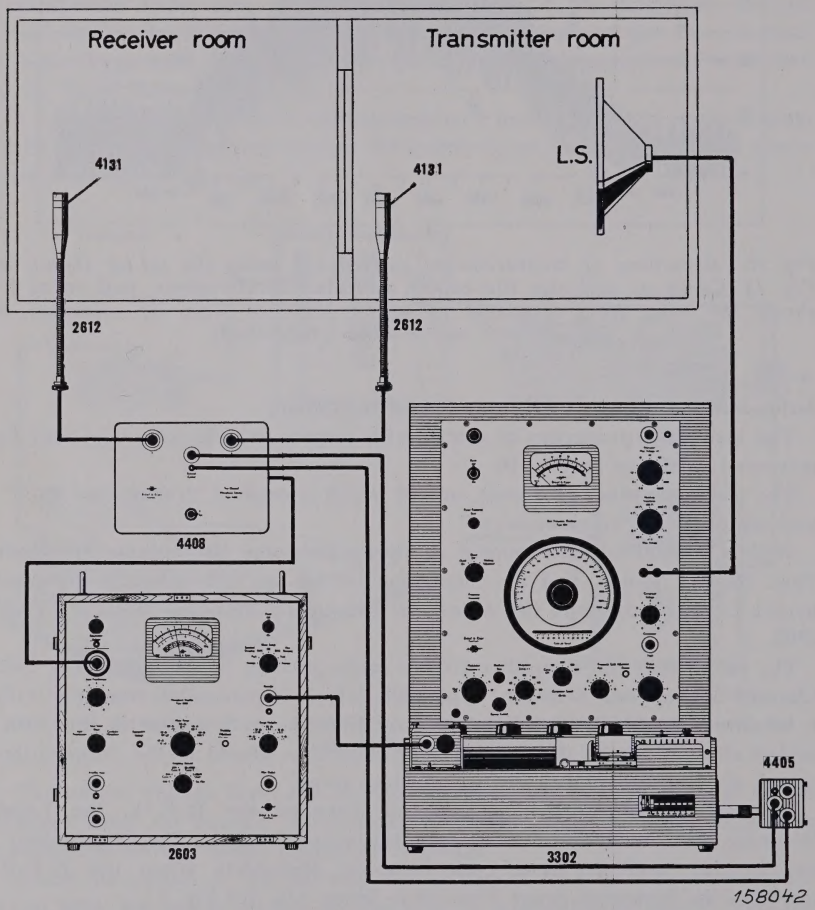


Fig. 16. Measuring arrangement for automatic recording of the sound insulation properties of a wall.

For dwellings the correction factor, the correction factor X is 10 log, is 10 log (2 . T) where T is the reverberation time of the room.

For laboratory measurements a Sound Reduction Factor can be employed. This factor is the ratio of the sound energy striking the test specimen per

second in the transmitter room, to the energy radiated per second from the test specimen to the receiver room, and is given by:

$$R = L_1 - L_2 + 10 \log \frac{S}{A},$$

where S is the area of the test specimen and A is the total absorption of the receiver room. This correction can thus be avoided by adjusting the receiver room's absorption to equal the area of the test wall.

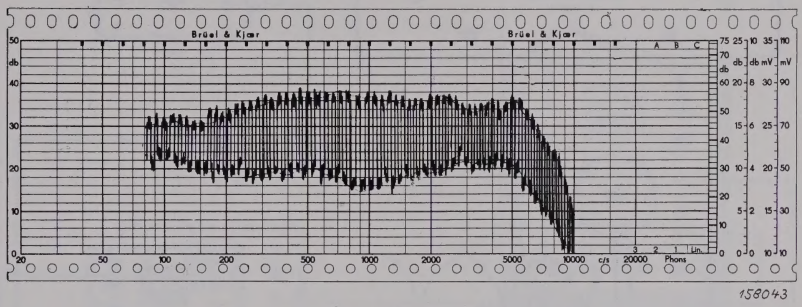


Fig. 17. Recording of measurements carried out with an arrangement as shown in fig. 16. A 50 db potentiometer is used on the Level Recorder.

Measurement of Acoustic Absorption Coefficients.

The acoustic absorption coefficient of small samples can be measured by means of the Standing Wave Apparatus Type 4002, see Fig. 18.

The apparatus is connected, as shown, to a beat-frequency oscillator, for example Type 1014, and the microphone built into the microphone carriage is connected to the Microphone Amplifier Type 2603. By inserting the sample to be measured at the end of the measuring tube standing waves are produced and the maxima and minima can be measured by moving the microphone carriage. The ratio between the maxima and minima determines the acoustic absorption coefficient of the sample. The indicating meter of the Amplifier is equipped with a set of scales, from which the absorption coefficient can be read directly.

At the top of the figure can be seen the instrument scale with three ranges, 0 to 100 %, 0 to 70 %, and 0 to 30 %. The microphone carriage is first placed at a point where the sound pressure is maximum and the amplification of Type 2603 adjusted so that the meter pointer gives full deflection. The microphone carriage is then displaced to a position of minimum sound pressure and the absorption read in per cent directly from the Amplifier meter scale gradated 0—100 %. By increasing the amplification by 10 or 20 db before taking the minimum reading, the absorption coefficient can be read on the scale 0—70 % or 0—30 %.

Standing Wave Apparatus Type 4002 is equipped with 2 measuring tubes, one of which should be used for measurements in the frequency range 95 to

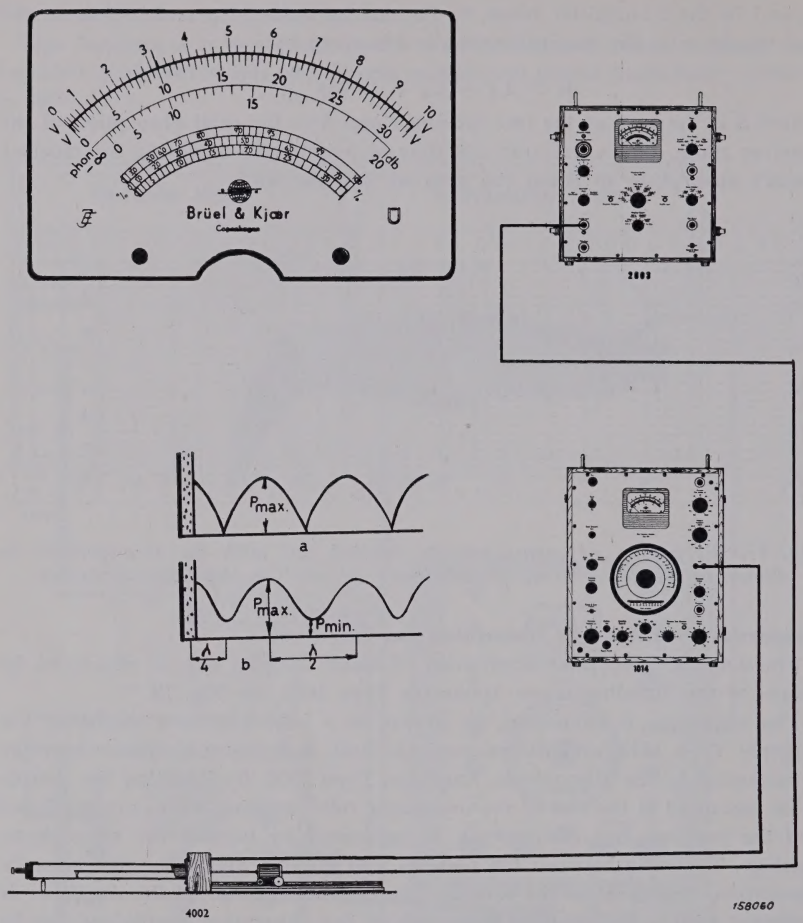


Fig. 18. Measurements on sound absorbing material by means of the Standing Wave Apparatus Type 4002.

1800 c/s and the other one for measurements in the range 800—6500 c/s. Acoustic absorption materials with absorption coefficients ranging from approximately 4 % to 100 % can be measured with this apparatus.

For further information see the instruction book for the Standing Wave Apparatus Type 4002.

Microphone Amplifier 2603 used as Compressor-Amplifier.

The Microphone Amplifier 2603 is very well suited for use as compressor-amplifier, the built-in meter making direct calibration of the source possible.

A. Checking of Hearing Aids.

Fig. 19a shows an arrangement by means of which it is possible to record automatically the frequency characteristic of complete hearing aids under approx. free field conditions.

The hearing aid is placed in the Hearing Aid Test Box Type 4212, which consists of a small anechoic chamber with built-in loudspeaker and regulating microphone, — as well as an artificial ear. The chamber itself is effectively

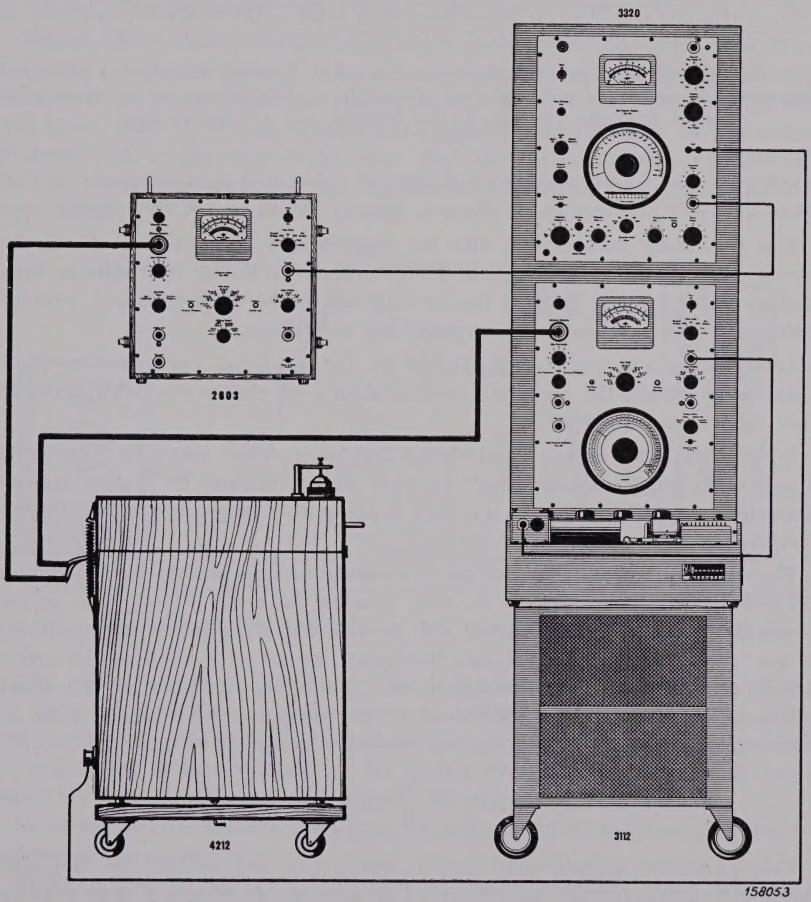


Fig. 19a. Checking of hearing aids. Measuring arrangement for automatic recording of frequency characteristics. Consisting of: The Hearing Aid Test Box Type 4212, the A. F. Response and Spectrum Recorder Type 3320, and a Microphone Amplifier Type 2603

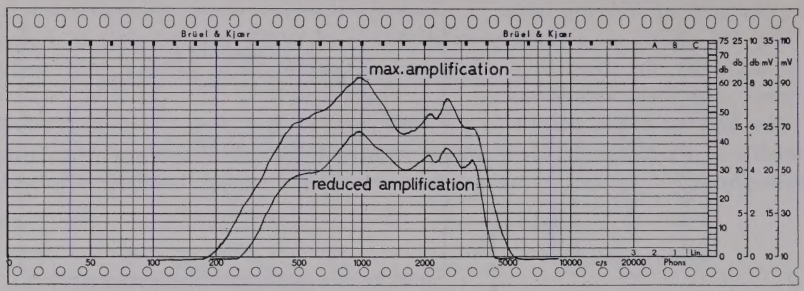


Fig. 19b. Typical frequency characteristic of a hearing aid device recorded automatically with the arrangement shown in a. Recordings were taken with two different settings of the hearing aid volume control.

insulated against both airborne and impact noise, and measurements can be taken at sound pressure levels down to approx. 50 db re 2×10^{-4} μbar.

The regulating microphone and the hearing aid being tested should be placed symmetrically in the sound field. The regulating microphone then enables the reference level at the hearing aid to be kept constant, without influencing the practically free sound field conditions.

The hearing aid receiver is placed in the artificial ear whereby it is possible to obtain the frequency characteristic of the device with acoustic input and acoustic output.

In the measuring arrangement shown the Microphone Amplifier Type 2603 is used as "compressor amplifier", i.e. it is used to amplify the output voltage from the regulating microphone and feeding the amplified signal to the compressor input of the Oscillator.

The filter switch on the front-panel of the Amplifier should be in position "20—35000 c/s Curve C". It is now possible to read directly the sound pressure in front of the hearing aid, as follows: By reading the positions of the "Meter Range" and "Range Multiplier" switches, as well as the meter deflection itself, the input voltage to the Amplifier is found. If the input voltage is X mV, and the sensitivity of the Condenser Microphone used as regulating microphone is S mV/μbar, the sound pressure in μbar is:

$$\text{S.P.} = \frac{\text{X}}{\text{S}} \ \mu\text{bar}.$$

This procedure is extremely easy to carry out, and makes the Amplifier excellently suited for this application. Furthermore, to obtain a clear reading on the meter, the pointer should be brought at least to the middle of the scale. As the meter itself gives full deflection for an output voltage of 10 volts from the Amplifier, this ensures the "Compressor Input" of the B.F.O. to be fed with a sufficiently high regulating voltage.

To amplify the signal from the artificial ear the Audio Frequency Spectrometer Type 2110 is used. This instrument is included in the combined unit Type 3320 which also enables a complete analysis of the harmonic distortion produced in the hearing aid to be made automatically. Further information concerning Type 3320 is found in the instruction manual for the Beat Frequency Oscillator Type 1014.

Fig. 19b shows some typical frequency characteristics of an hearing aid device obtained with the measuring arrangement of fig. 19a.

B. Measurements at High Sound Pressure Level.

Where high sound pressure levels are required the Constant Sound Pressure Source Type 4211 should be used as sound source. A set-up for measurements on an air filter of an automobile is shown in Fig. 20. One of the Amplifiers 2603 is used as compressor-amplifier and indicator of the sound pressure level at the inlet of the filter, the other as microphone preamplifier for the Level Recorder of the Automatic Frequency Response Recorder Type 3302.

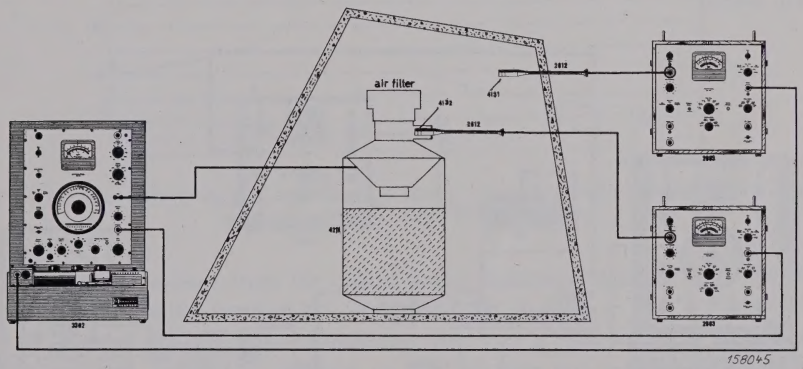


Fig. 20. Arrangement for determining the sound attenuation in an airfilter.

The curves shown in Fig. 21 give an indication of the attenuation of the air filter for sound waves. Curve a) is measured with open Source 4211, and curve b) with the filter mounted on the opening of the Source, the sound pressure level at the "mouth" of the Sound Pressure Source in both cases being 110 db with reference to 2×10^{-4} μbar.

To avoid any directivity influence the measurements were carried out in a reverberant room.

In many cases it might be convenient to deduce at which places absorbing patches can be most effectively mounted for the purpose of silencing the object under test. Measurements should then be carried out under free field conditions or in a "dead" room, whereby the directivity pattern of the object can be obtained.

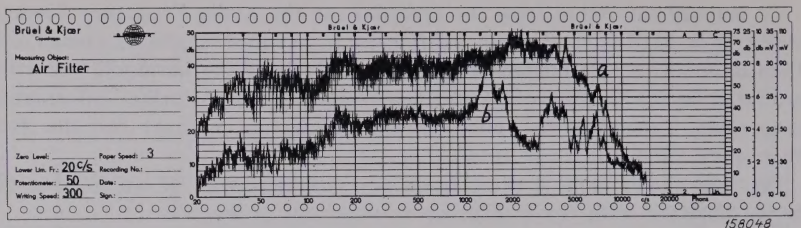


Fig. 21. Determination of the air filter's sound attenuation: Curve a) measurements without air filter, curve b) measurements with air filter mounted on top of the Constant Sound Pressure Source 4211.

C. Measurements of Mechanical Strain in Objects Subjected to Vibrations.

When measuring the mechanical strain in objects subjected to vibrations, it is of importance that resonances of the system do not affect the magnitude of the driving force. The acceleration of the vibrations should therefore be kept constant throughout the range of frequencies at which measurements are taken.

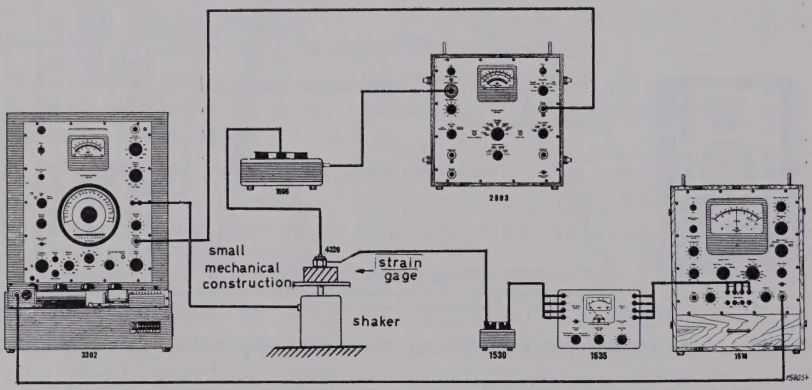


Fig. 22. Set-up for the measurement of vibrations in small mechanical constructions.

Fig. 22 shows an arrangement for measurements on small mechanical constructions. The object to be measured is placed on a shaker table, the shaker being fed from the Beat Frequency Oscillator of the Automatic Frequency Response Recorder Type 3302; the acceleration is kept constant by means of a control system.

This system consists of an Accelerometer Type 4308, the output voltage of which is fed to the "Compressor Input" of the B. F. O. of 3302, via a Preamplifier Type 1606 and a Microphone Amplifier Type 2603. The switch on the top panel of the Preamplifier 1606 should be set to position

"Acceleration", and the filter switch of the Microphone Amplifier 2603 to position "20—35000 c/s Curve C". By using the built-in meter of the Amplifier the output voltage from the Accelerometer can be observed and the acceleration calculated from the Acceluerometer's sensitivity curve.

The mechanical strain in the object under test is measured by means of strain gages. A strain gage is a specially designed resistance-slip, which can be glued onto the test object, and when this is subjected to mechanical strain the resistance of the gage changes. By means of a sensitive bridge arrangement the change in resistance due to the strain can be measured. Further information concerning strain gage measurements is given in the manual for the Strain Gauge Apparatus Type 1516.

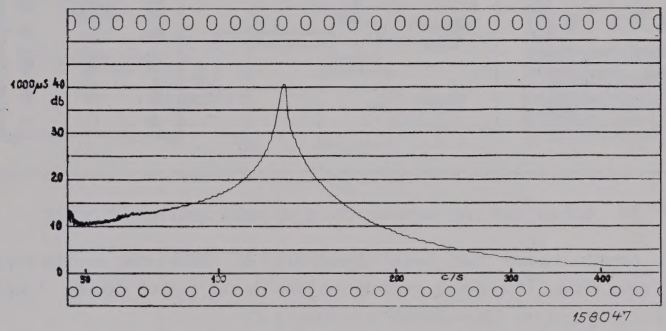


Fig. 23. Recording of the mechanical strain of a thin bar. Measured with an arrangement as shown in Fig. 22.

The output voltage from the Strain Gauge Apparatus used in the set-up of Fig. 21 is fed to the input of the Level Recorder of 3302.

A recording showing the mechanical strain of a thin bar, and indicating its resonance frequency, is given in Fig. 23. For the recording the set-up of Fig. 22 was used.

D. Measurement of Microphony in Vacuum Tubes.

A set-up for measurement of microphone in tubes is shown in Fig. 24. The tube and an Accelerometer Type 4308 is symmetrically mounted on a shaker which is driven from the Beat Frequency Oscillator of the Frequency Response Recorder Type 3302.

The output voltage from the Accelerometer is fed to the "Compressor Input" of the B.F.O. by means of a circuit as described under C., whereby the vibrating force acting on the tube is kept constant.

A diagram of the circuit used for measurements on a Philips tube, ECC82, is given in Fig. 25. The AC voltage developed across the anode load is fed

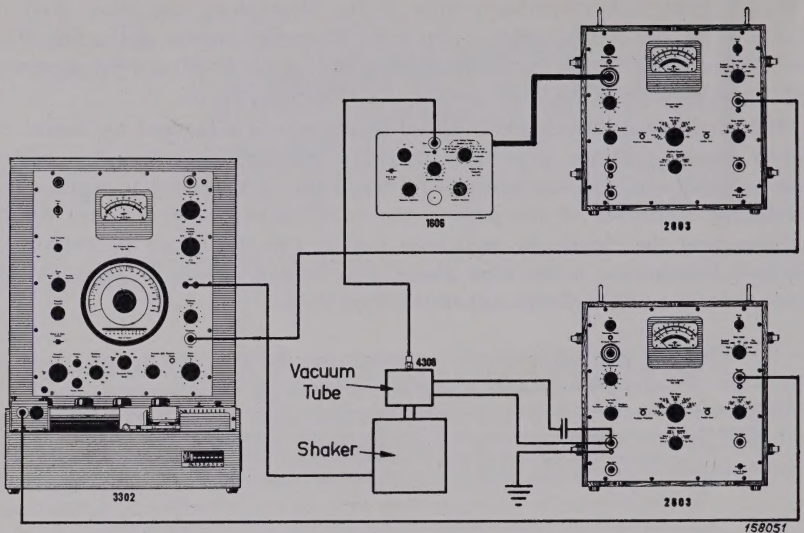


Fig. 24. Set-up for the measurement of microphony in tubes.

onto input terminals of the Level Recorder of 3302 via a Microphone Amplifier Type 2603. The filter switch on the front panel of the Amplifier should be set to position "20—35000 c/s Curve C".

Fig. 26 shows a recording obtained with the set-up described above.

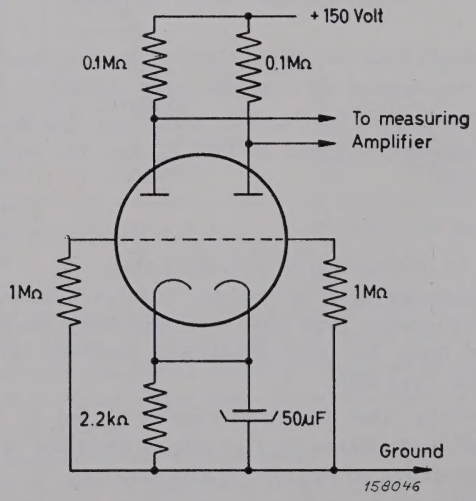


Fig. 25. Circuit diagram for measuring the microphony in a Philips tube ECC82.

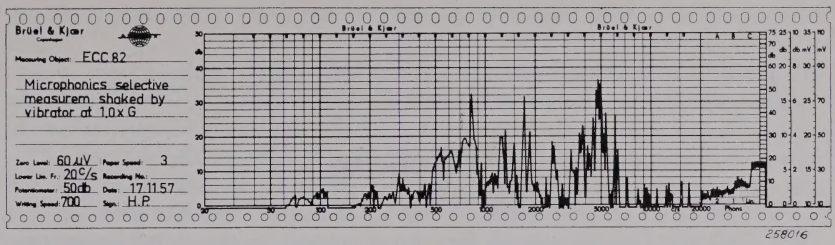


Fig. 26. Recording of the measurements carried out on ECC82.

Appendix.

A. Some Notes on the Arithmetic Average, R.M.S. and Peak Rectifier.

The "value" of an AC signal may be expressed as the *aritmetic average value* of the signal, normally defined by the expression:

$$S_{a.a.} = \frac{1}{T} \int_0^T |s(t)| \, dt$$

where T is the time interval between two successively following moments of equal phase, see Fig. 27.

A second method of expressing the value of the signal is by means of its *root mean square* (r.m.s.) *value* defined by:

$$S_{r.m.s.} = \sqrt{\frac{1}{T} \int_0^T (s(t))^2 \, dt}$$

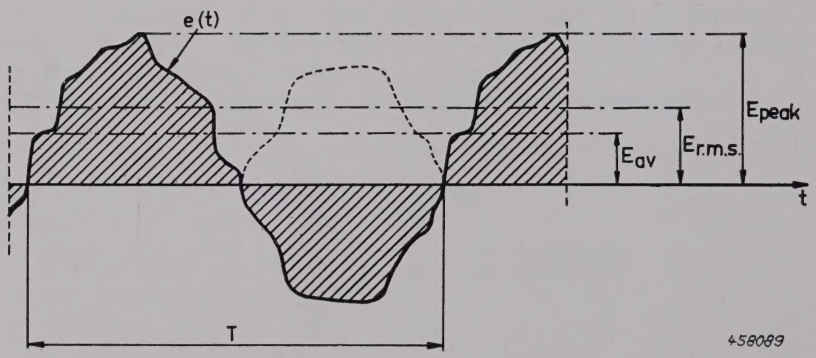


Fig. 27. Example of a periodic signal with indication of the peak, r.m.s. and arithmetic average value of the voltage.

Finally, it is sometimes desired to know the max. value that the signal may reach within a certain time interval (a period), and this value is known as the *peak value* of the signal.

In Fig. 27 the significance of the above definitions with regard to a periodic signal of period T is indicated.

To obtain a meter indication on a measuring instrument which is designed to measure AC signals over a wide frequency range some sort of rectifier arrangement must be incorporated in the circuit. The rectifier then transforms

the AC signal voltage into the DC voltage necessary to feed a moving coil meter.

It is now possible to give the rectifier circuit characteristics making the meter indication proportional to any one of the above mentioned "values" of the AC input signal.

The rectifier circuit employed in Type 2603 is designed, however, to enable not only the measurement of the arithmetic average, but also the true r.m.s. and the peak value of AC signals in the frequency range 2 to 35000 c/s.

In nearly all practical applications of the Microphone Amplifier the r.m.s. indication will be the most important type of indication, because it has a direct connection to the energy content of the signal being measured.

However, the possibility of measuring both the r.m.s. value and the arithmetic average value of complex signals is of considerable interest also in normal laboratory work. It is, for instance, possible by means of Type 2603 to establish correction factors for simple average type indicating voltmeters when applied to certain specific measurements of complex signals.

The measurement of signal peak values is convenient when the limiting effects of non linear electronic components are investigated.

Furthermore, from the measurement of the peak, the average and the r.m.s. value of a periodic signal the crest factor and the form factor of the signal can be calculated.

The crest factor is defined as:

$$f_c = \frac{S_{peak}}{S_{r.m.s.}}$$

and the form factor:

$$f_f = \frac{S_{r.m.s.}}{S_{average}}$$

From these expressions are readily seen that the crest factor of sharp periodic pulses must be high, while the crest factor, as well as the form factor for an ideal square-wave is exactly 1. It is thus possible, in some cases, by means of the crest factor and the form factor to obtain a rough picture of the signal wave shape.

B. Weighting Networks for Sound Level Measurements.

When measurements are taken with an equipment consisting of a microphone, amplifier and indicating meter having a linear frequency characteristic in the range 20 c/s to 20000 c/s (or higher) an indication of the absolute *sound pressure level* is obtained. This indication (in μbar) is useful for many physical investigations.

However, the sound pressure level measured with a linear frequency characteristic does not immediately give an indication of the human ear's perception of the sound's strength, because the ear is less sensitive to sounds of both low and high frequencies in comparison with the middle frequencies. This variation of sensitivity with frequency is very complicated

as the absolute sound level also plays an important role. Sounds that seem to the ear to be equally loud are said to have the same subjective strength or loudness. Loudness is expressed in phons. In determining the loudness, the sound is compared with a tone of 1ooo c/s whose physical energy is adjusted so that the sound and the 1ooo c/s tone appear to the ear to be of equal strenght. The loudness, expressed in phons, of the sound in question is then equal to the physical intensity of the 1ooo c/s tone

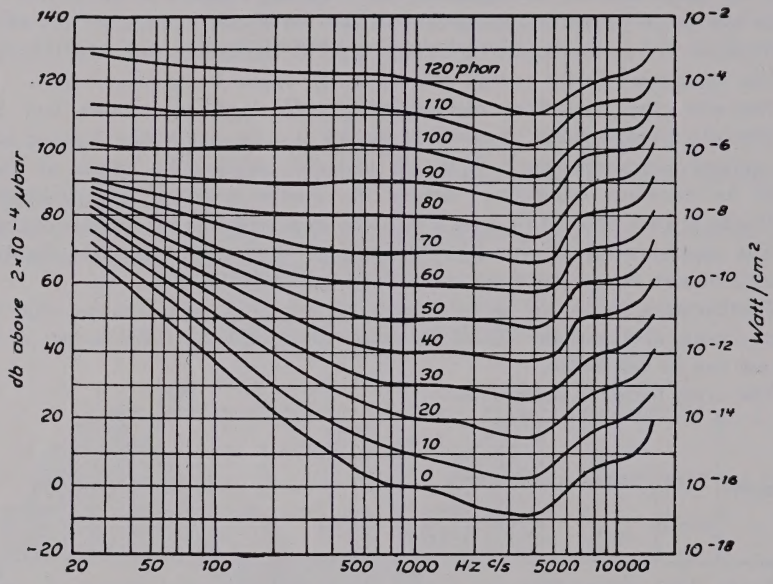


Fig. 28. The sensitivity curves for the human ear (Fletcher and Munson).

expressed in db above 2×10^{-4} μbars. At 1ooo c/s, therefore, phon scale and decibel scale become identical, but at all other frequencies they will be different. Fig 28 shows the sensitivity curves of the ear.

Accordingly the loudness in phons can only be found by subjective measurements, i.e. by means of the human ear.

However, an electrical instrument, such as a sound level meter, will give an indication of the sound level when equipped with filter networks depressing the high and low frequencies in a way corresponding to Fig. 28. Sound levels measured with such an instrument should be expressed in db *Sound Level* (db S.L.), thereby stating the difference between subjective and objective measurements of loudness.

It has been found sufficient for practical sound level meters to use only four different filter characteristics, each effective within certain level limits.

The characteristics used in Europe are laid down in DIN 5045, and in America slightly divergent standards are laid down in ASA Z 24.3.

The tolerances permitted both for the European and the American Standards are so great that it is possible to give an instrument frequency characteristics which satisfy both standard requirements. The standards also contain requirements for the sound level meter's dynamic characteristics, and overload safety factor. The Microphone Amplifier 2603, when equipped with one of the B & K Condenser Microphones, satisfies all these requirements within the permitted tolerances.

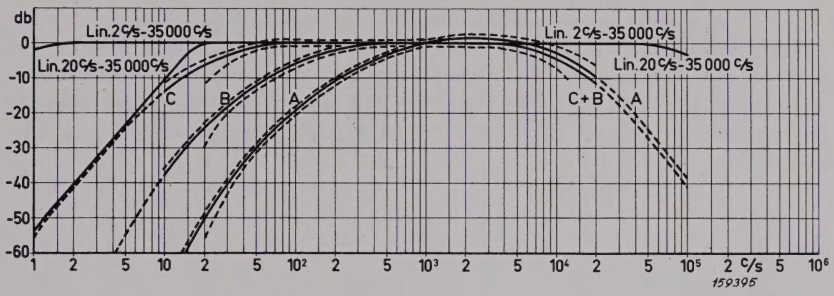


Fig. 29. Typical frequency characteristics of the Microphone Amplifier Type 2603. The A, B and C curves are accurate to within the following tolerances:

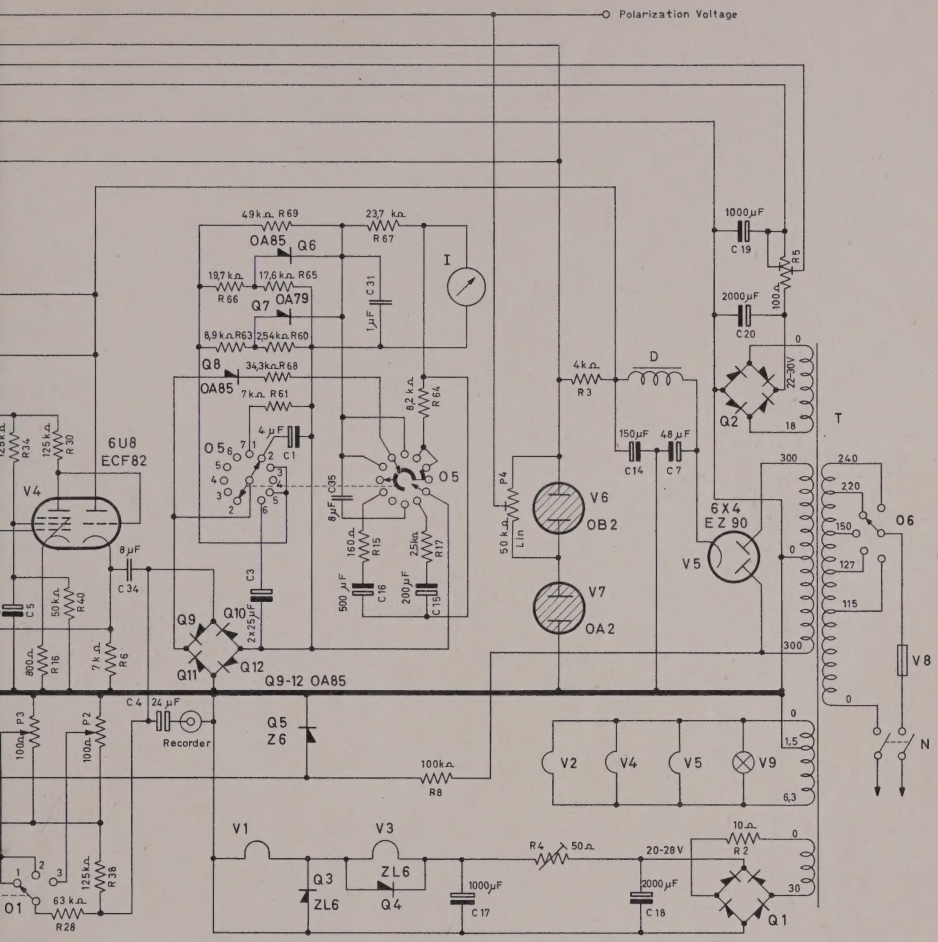
Frequency c/s	10	20	40	80	160	315	630	1000	2000	4000	8000	12500	20000
Curve A	-70.5	-50.4	-34.5	-22.3	-13.2	-6.5	-1.9	Ref	1.2	1.0	-1.1	-4.2	-9.2
Curve B	-38.5	-24.4	-14.2	-7.4	-3	-0.9	-0.1	Ref	-0.2	-0.8	-3.0	-6.0	-11.0
Curve C	-14.5	-6.3	-2.0	-0.5	-0,1	0	0	Ref	-0.2	-0.8	-3.0	-6.0	-11.1
Tolerance	+5	+5	+3	+2	+2	+2	+2	+1	+2	+3	+4	+5	+5
Ordinary Sound Level Meters	÷ ∞	÷ ∞	÷3	÷2	÷2	÷2	÷2	÷1	÷2	÷3	÷4	÷10	÷ ∞
Tolerance	+5	+5	+3	+2	+1	+1	+1	0	+1	+2	+3	+5	+5
Precision Sound Level Meters	÷ ∞	÷5	÷3	÷2	÷1	÷1	÷1	0	÷1	÷2	÷3	÷5	÷ ∞
Tolerance	+3	+2	+2	+1	+1	+1	+1	0	+1	+2	+2	+2	+3
Brüel & Kjær requirements	÷6	÷5	÷2	÷1	÷1	÷1	÷1	0	÷1	÷2	÷2	÷5	÷6

The Amplifier can be switched to show five different frequency characteristics four of which are to be used in sound level and noise measurements. These are all shown in Fig. 29.

Sound level measurements should be carried out with the filter switch of the Amplifier set to a position corresponding to the sound level to be measured, see table below.

Loudness	Weighting Network Inserted
0—30 phons	DIN 3
30—60 phons	DIN 2 — Curve A
60—130 phons	DIN 1 — Curve B
130 phons	20—35ooo c/s — Curve C

The fifth frequency characteristic of the Amplifier is linear from 2 c/s to 35ooo c/s and is used in vibration measurements when the Accelerometer Type 4308 (or 4309) and the Vibration Pick-up Preamplifier Type 1606 or the Cathode Followers Type 2612 or 2613 with Adapter JJ 2612 are employed.



O1: Input Switch	O2: Meter Range	O3: Frequency Response Switch	O4: Range Multiplier	O5: Meter Switch
1: Potentiometer	1: 10 mV	1: Weighting Curve A.	1: x 0,01	1: Average Fast
2: Direct	2: 100 mV	2: " " B.	2: x 0,03	2: Peak "
3: Condenser Microphone	3: 1V	3: " " C.	3: x 0,1	3: RMS "
	4: 10V	4: Linear 20-35000	4: x 0,3	4: Off
	5: 100 V	5: Linear 2-35000	5: x 1	5: RMS Slow
	6: 1000 V	6: External Filter		6: Peak "
	7: Ref.			7: Average "

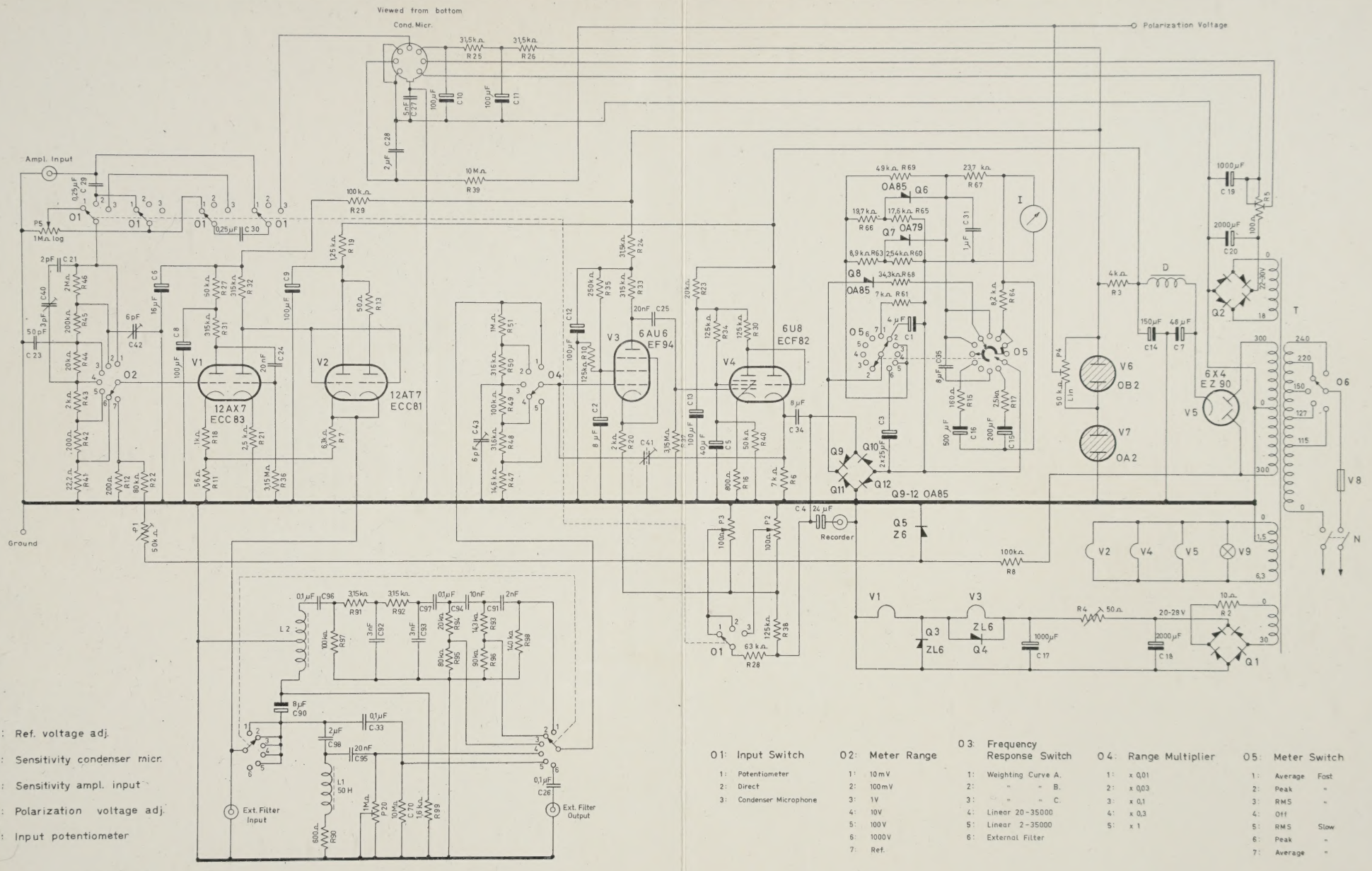
2-58				
1-59	42727			
12-59	48345			

Brüel & Kjær
Copenhagen

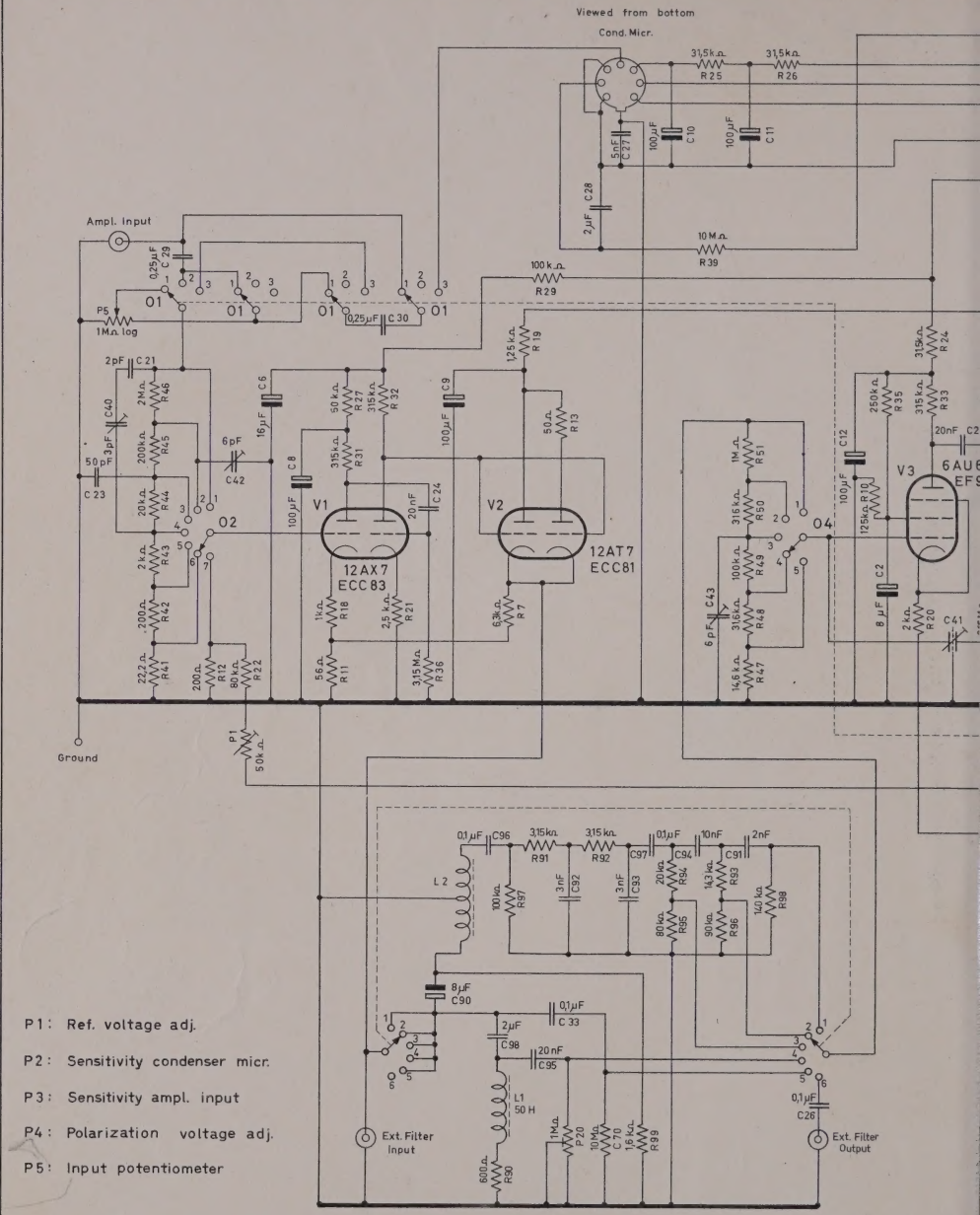
Microphone Amplifier
Type 2603

Loudness	Weighting Network Inserted
0—30 phons	DIN 3
30—60 phons	DIN 2 — Curve A
60—130 phons	DIN 1 — Curve B
130 phons	20—35000 c/s — Curve C

The fifth frequency characteristic of the Amplifier is linear from 2 c/s to 35000 c/s and is used in vibration measurements when the Accelerometer Type 4308 (or 4309) and the Vibration Pick-up Preamplifier Type 1606 or the Cathode Followers Type 2612 or 2613 with Adapter JJ 2612 are employed.



1-2-58				Brüel & Kjær Copenhagen
10-11-59	42727			Microphone Amplifier Type 2603
21-12-59	48345			


Viewed from bottom
Cond. Micr.
Ampl. Input
Ground
P1: Ref. voltage adj.
P2: Sensitivity condenser micr.
P3: Sensitivity ampl. input
P4: Polarization voltage adj.
P5: Input potentiometer
Ext. Filter Input
Ext. Filter Output
12AX7 ECC83
12AT7 ECC81
6AU6 EF94
6U8 ECF82
6X4 EZ90
OB2
OA2

Service Instructions
Microphone Amplifier

Consisting of:

Meter Circuit	2603.1
Output Amplifier	2603.2
Input Amplifier	2603.3
Weighting Network	2603.4
Position of Components	2603.5
Parts List	2603.6
Circuit Diagram	2603.7

Removal of the Metal Case

After removing the four threaded retainers at the back of the instrument, it is possible to slide the chassis and the front panel out of the case.

Trouble Shooting

If the reason for a fault is not an obvious one such as a dead tube, broken down resistor, blown or disconnected fuse etc., then first test the voltages of all the tubes and compare them with the voltages shown in the circuit diagram in order to localize the defect. Should this method of finding the fault prove unsuccessful, then check the instrument by adopting the method described in the adjustment procedure. When the trouble has been found and remedied, the voltages and adjustments which are influenced by the remedy must be rechecked.

The tolerances stated in the instructions can only be used as a guide for adjustment and control, but any deviations must not be corrected without being sure that the tolerances of the instruments used for making the adjustment are so small as to have no influence on the measurements.

The instructions in this Manual are given purely as a guide to the service of equipment. Some faults, as f.i. small deviations in tolerances require for their correction special control equipment and extensive experience, and in these cases it is necessary to send the instrument to the factory.

Instruments and accessories necessary for service and repair:

Multimeter (50 μA)
Frequency Analyzer type 2107
Beat Frequency Oscillator type 1022
Pistonphone type 4220
Cathode Follower type 2612/2613
Condenser Microphone type 4131/32

OA2

Meter Circuit

valid from serial no. 67708

2603.1

1.1. Mechanical Zero-Point

METER SWITCH: "Off"
POWER: "Off."

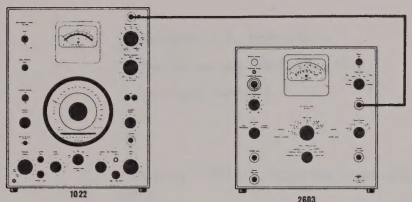
Adjust for zero deflection.

1.2. Electrical Zero-Point

METER RANGE: "10 V"
RANGE MULT.:"X 1"
POWER: "On"

Check that the instrument is still at zero deflection.

Tolerance: "1/2 pointer width".



1.3. Check of Meter Switch

a. METER SWITCH: "RMS fast"
POWER:"Off."

Frequency: 1000 c/s. Adjust the input voltage for a 16 dB deflection on type 2603.

b. METER SWITCH to "Average fast"

Deflection on type 2603: 14.9-15.3 dB.
If necessary adjust P6.

c. METER SWITCH to "Peak fast"

Deflection on type 2603: 18.5-19.5 dB.
If necessary adjust P6 and repeat item b.

Also check a-b-c at 20 c/s in pos. "fast"
20.000 c/s " " "

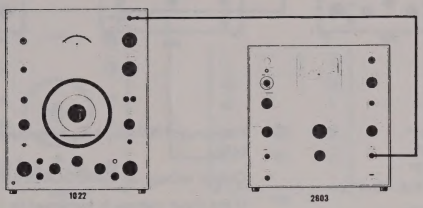
1.4. Sensitivity

METER SWITCH: "RMS fast"
POWER: "Off"

Frequency: 1000 c/s. Adjust the input voltage for a full scale deflection on type 2603. The input voltage from type 1022 should be with 8-11 V.

Output Amplifier 2603.2

valid from serial no. 110125



2.1. Sensitivity

a. RANGE MULT.:"X 1"
METER SWITCH: "RMS"
INPUT SWITCH: "Direct"
FREQ.RESP.SWITCH: "Ext.filter"

Input signal: 1 V. 1000 c/s.

Deflection on type 2603: app. 10 V.

If not check item: 3.6.

2.2. Range Multiplier

INPUT SWITCH: "Direct"
METER SWITCH: "RMS"
RANGE MULT."X 1"
FREQ.RESP.SWITCH: "Ext.filter"

Frequency: 1000 c/s. Adjust the input voltage for an 18 dB deflection on type 2603.

Check the steps of RANGE MULT. by comparison to type 1022.

Tolerance: $\pm$ 0.2 dB (+ tolerance of type 1022: 0.2 dB)

Possible reasons for fault: defective tube V 4
" capacitor C 2.

2.3. Frequency Response. Check

a. INPUT SWITCH: "Direct"
METER SWITCH:"RMS"
RANGE MULT.:"X 1"
FREQ.RESP.SWITCH:"Ext.filter"

The apparatus must be placed in its case or in other way effectively screened.

Frequency: 1000 c/s. Adjust the input voltage for an 18 dB deflection on type 2603.

Vary the frequency from 20-20.000 c/s and check the deflection on type 2603.

Tolerance: $\pm$ 0.2 dB (+ tolerance of type 1022: 0,3 dB)

2.4. Frequency Response. Adjustment

a. INPUT SWITCH: "Direct"
METER SWITCH: "RMS"
RANGE MULT.:"X 0.3"
FREQ.RESP.SWITCH: "Ext.filter"

Frequency: 1000 c/s. Adjust the input voltage for an 18 dB deflection on type 2603.

Change frequency to 20.000 c/s and adjust C 41 for an 18 dB deflection on type 2603.

b. RANGE MULT. to X 0.1

as item a, but adjust C 43 for an 18 dB deflection on type 2603.

Possible reasons for fault: defective tubes V 4 - V 5.

Whenever V 5 is replaced, P 24 should be adjusted to V_k triode (pin 8, V 5)is 105 V d.c.

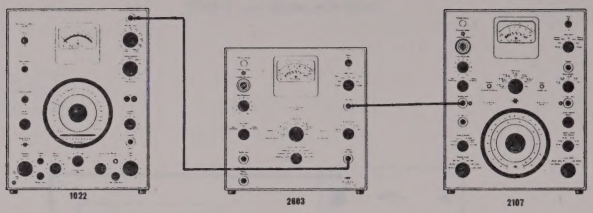
2.5. Output Impedance

INPUT SWITCH: "Direct"
METER SWITCH: "Peak"
RANGE MULT.:"X 1"
FREQ.RESP.SWITCH: "Ext.filter"

Frequency: 1000 c/s. Adjust the input voltage for a 20 dB deflection on type 2603.

When loading the RECORDER socket with a resistor of 1000 Ω the deflection should be within 19.5 - 20 dB.

If necessary adjust P 24 or change V 5 and check d.c. voltage on V 5 pin 8: 95 - 115 V.



2.6. Output Voltage

a. INPUT SWITCH:"Direct"
METER SWITCH: "RMS"
RANGE MULT.:"X 0.3"
FREQ.RESP.SWITCH:"Ext.filter"

Frequency: 1000 c/s. Adjust the input voltage for a 20 dB deflection on type 2603.

Output voltage on the RECORDER socket: 8-11 V.

b. METER SWITCH to "Off"

If the input voltage is increased by 10 dB the output voltage should increase by 9.7 - 10.3 dB.

2.7. Noise - Hum.

a. INPUT SWITCH: "Direct"
RANGE MULT.:"X 1"
FREQ.RESP.SWITCH: "Ext.filter"
METER SWITCH: "RMS"

The apparatus must be placed in its case or in other way effectively screened.

Disconnect type 1022 and measure hum at line frequency and 2nd and 3rd harmonic.

Tolerance: max. 5 mV hum
max. 10 mV noise

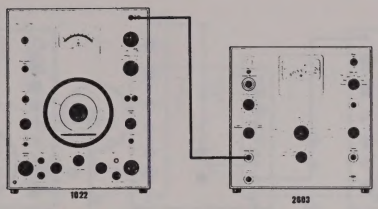
b. RANGE MULT. to "X 0.01"

Tolerance: max. 10 mV hum
max. 20 mV noise

Possible reasons for fault: defective tube V4.

Input Amplifier 2603.3

valid from serial no. 110125



3.1. Meter Range

INPUT SWITCH:"Direct"
METER RANGE: "10 V"
FREQ.RESP.SWITCH:"Lin.20-40.000 c/s"
RANGE MULT.:"X 1"
METER SWITCH:"RMS"

Frequency: 1000 c/s. Adjust the input voltage for an 18 dB deflection on type 2603.

Check the steps of METER RANGE by comparison to type 1022.

Tolerance: $\pm$ 0.2 dB (+ tolerance of type 1022: 0.2 dB)

Possible reasons for fault: defective tubes V 1 - V 2.

3.2. Frequency Response Check

INPUT SWITCH: "Direct"
METER RANGE:"10 V"
FREQ.RESP.SWITCH:"Lin.2-40.000 c/s"
RANGE MULT.:"X 1"
METER SWITCH:"RMS"

Frequency: 1000 c/s. Adjust the input voltage for an 18 dB deflection on type 2603.

Vary the frequency from 20 - 20.000 c/s.

Deflection on type 2603: 18 dB.

Tolerance: $\pm$ 0.3 dB (+ tolerance of type 1022: 0.3 dB)

3.3. Frequency Response. Adjustment.

a. INPUT SWITCH:"Direct"
METER RANGE:"100 mV"
FREQ.RESP.SWITCH:"Lin.2-40.000 c/s"
RANGE MULT.:"X 1"
METER SWITCH: "RMS"

The apparatus must be placed in its case or in otherway effectively screened.

Frequency: 1000 c/s. Adjust the input voltage for a 20 dB deflection on type 2603.

Change frequency to 20.000 c/s and adjust C 42 for a 20 dB deflection on type 2603.

b. METER RANGE to "10V"

As under item a but adjust C 40 for a 20 dB deflection on type 2603.

c. Check all steps of METER RANGE

Vary the frequency from 20-20.000 c/s.

Tolerance: $\pm$ 0.3 dB (+ tolerance of type 1022: 0.3 dB)

3.4. Overload Indicator

INPUT SWITCH: "Direct"
METER RANGE: "1 V"

Input signal: 1 V 1000 c/s.

The indicator should light up if the input voltage increases by 9 - 11 dB.

Also check at frequencies from 20 - 20.000 c/s.

3.5. Output Impedance

INPUT SWITCH:"Direct"
METER RANGE:"10 V"
FREQ.RESP.SWITCH:"Lin.2-40.000 c/s"
RANGE MULT.:"X 0.1"
METER SWITCH:"RMS"

Load the EXT.FILTER INPUT socket with a resistor of 500 Ω in series with a 50 µF capacitor.

Set frequency to 1000 c/s and adjust the input voltage for a 20 dB deflection on type 2603.

When changing the resistor to 50 Ω the deflection on type 2603 should be within 19-20 dB.

3.6. Reference

a. INPUT SWITCH:"Direct"
METER RANGE: "10 V"
RANGE MULT.:"X 1"
METER SWITCH:"RMS"
FREQ.RESP.SWITCH:"Lin.2-40.000 c/s"

Frequency: 1000 c/s. Adjust the input voltage to exactly 10 V.

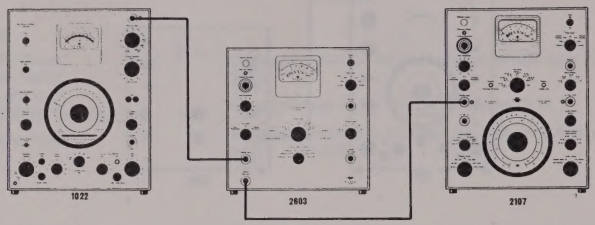
Adjust P 3 SEN.AMPL.INPUT for full scale deflection on type 2603.

b. METER RANGE to "Ref."

Adjust P 1 for deflection to the red line on type 2603.

c. INPUT SWITCH to "Cond.micr."

Adjust P 2 SEN.COND.MICR. for deflection to the red line on type 2603.



3.7. Distortion

INPUT SWITCH: "Direct"
METER RANGE: "10 V"
FREQ.RESP.SWITCH: "Ext.filter"

Distortion down to around 0.5% can be measured by type1022 and type 2107 only. Lower distortion requires the use of a filter type 1607 connected between type 2603 and type 2107 for rejection of fundamental frequency and a filter connected between type 1022 and type 2603 to ensure that the distortion of the input signal is below 0.01%.

If these filters are available check limits.

Adjust the input voltage for 1 V on EXT. FILTER INPUT socket which is loaded with a resistor of 500 Ω in series with a 50 μF capacitor.

Measure distortion at 40 - 1000 - 6500 c/s.

Tolerance: max. 0.1% 2nd harmonic
max. 0.1% 3rd harmonic

3.8. Noise - Hum

a. INPUT SWITCH:"Potentiometer"
METER RANGE: "10 mV"
FREQ.RESP.SWITCH: "Ext.filter"
INPUT POTENTIOMETER: 10

The apparatus must be placed in its case or in other way effectively screened.

Disconnect type 1022 and measure hum at line frequency and 2nd and 3rd harmonic.

Tolerance: max. 200 μV hum
max. 1.5 mV noise

b. INPUT POTENTIOMETER: 0

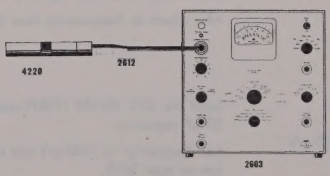
Tolerance: max. 200 μV hum
max. 500 μV noise

Possible reasons for fault: defective tube V 1
" resistor R 31.

3.9. Polarization Voltage

Connect a multimeter to POL.VOLTAGE socket and check the d.c. voltage: 200 V.

If necessary adjust P 4.



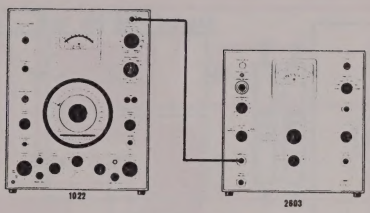
3.10. Acoustical Calibration

INPUT SWITCH: "Cond.micr."
METER RANGE: "120 dB SL"
FREQ.RESP.SWITCH:"Lin.20-40.000 c/s"
RANGE MULT.:"-10 dB"
METER SWITCH: "RMS fast"

Switch on the pistonphone and adjust P 2 SEN.COND.MICR. until the deflection on type 2603 is equal to the SPL produced by the pistonphone, with, for example, a pistonphone producing 124.1 dB the deflection should be 14.1 dB.

Weighting Network 2603.4

valid from serial no. 67708



4.1. Linear

METER SWITCH: "RMS"
INPUT SWITCH: "Direct"
RANGE MULT.: "X 1"
FREQ.RESP.SWITCH:"Lin.2-40 000 c/s"
METER RANGE: "10 V"

Frequency: 1000 c/s. Adjust the input voltage for an 18 dB deflection on type 2603.

Change frequency to 50 c/s.
Deflection on type 2603: 18 dB.
Tolerance: ± 0.1 dB (+ tolerance of type 1022: 0.3 dB)
If necessary adjust R 99.

Vary the frequency from 20 - 20.000 c/s.
Deflection on type 2603: 18 dB.
Tolerance: ± 0.3 dB (+ tolerance of type 1022: 0.3 dB)

4.2. Curve A-B-C. Check.

a. METER SWITCH: "RMS"
INPUT SWITCH: "Direct"
RANGE MULT.: "X 1"
FREQ.RESP.SWITCH: "Lin.2-40.000 c/s"
METER RANGE: "10 V"

Frequency: 1000 c/s. Adjust the input voltage for an 18 dB deflection on type 2603.

b.

Freq.	Curve "A" Defl.on type 2603	Range Mult.	Curve "B" Defl.on type 2603	Range Mult.	Curve "C" Defl.on type 2603	Range Mult.
c/s	dB		dB		dB	
20	4.6-12.6	X 0.01	10.6-18.6	X 0.1	8.7-16.7	X 1
63	10.4-13.9	X 0.1	7.1-10.6	X 1	15.7-19.2	X 1
500	14.4-15.2	X 1	17.3-18.1	X 1	17.6-18.4	X 1
1000	17.7-18.3	X 1	17.7-18.3	X 1	17.7-18.3	X 1
2000	19.0-19.4	X 1	17.6-18.0	X 1	17.6-18.0	X 1
8000	15.7-17.4	X 1	13.8-15.5	X 1	13.8-15.5	X 1
20.000	6.8-10.3	X 1	15.0-18.5	X 0.3	14.9-18.4	X 0.3

4.3. Curve A-B-C. Adjustment at 1 kc/s.

a. METER SWITCH: "RMS"
INPUT SWITCH:"Direct"
RANGE MULT.:"X 1"
FREQ.RESP.SWITCH:"Lin.2-40 000 c/s"
METER RANGE: "10 V"

Frequency: 1000 c/s. Adjust the input voltage for an 18 dB deflection on type 2603.

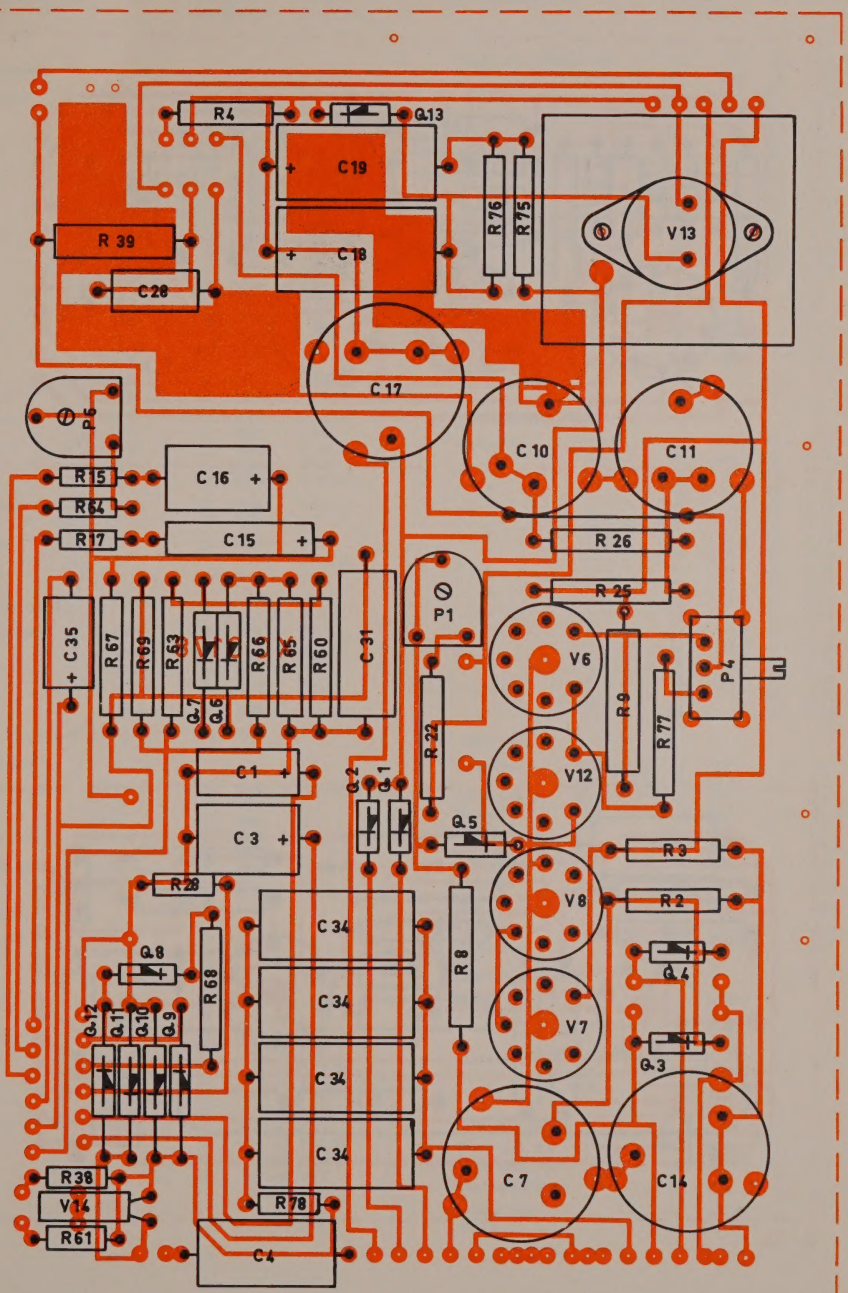
b. FREQ.RESP.SWITCH to curve "A" — Adjust R 98 for an 18 dB deflection on type 2603.

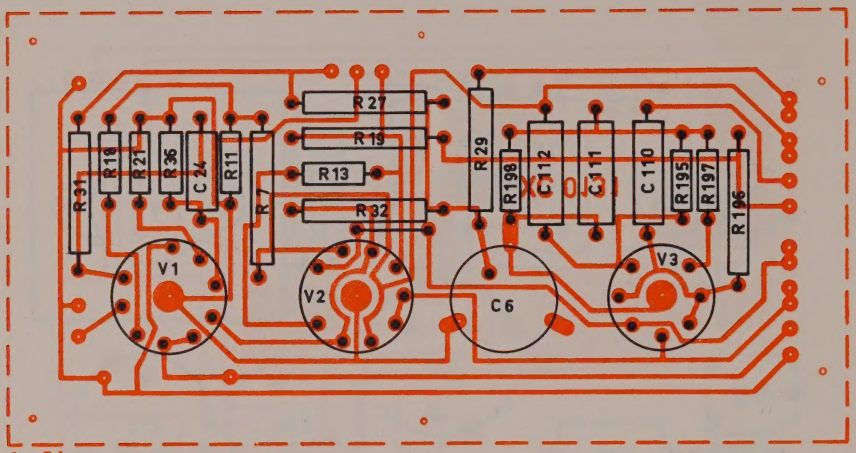
c. FREQ.RESP.SWITCH to curve "B" — Adjust R 97 for an 18 dB deflection on type 2603.

d. FREQ.RESP.SWITCH to curve "C" — Adjust R 94 for an 18 dB deflection on type 2603.

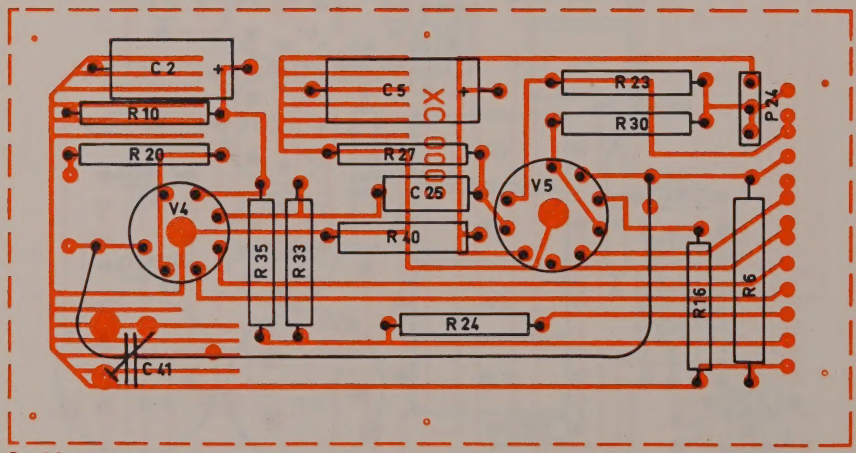
Position of Components 2603.5

valid from serial no. 110125




R 27
R 19
R 13
R 32
R 29
R 198
C 112
C 111
C 110
R 195
R 197
R 196
R 31
R 18
R 21
R 36
C 24
R 11
R 7
V1
V2
C 6
V3

1-64


C 2
R 10
R 20
C 5
R 23
R 30
P 24
R 27
C 25
R 40
V4
V5
R 35
R 33
R 24
R 16
R 6
C 41

6-64

Parts - List

2603.6

valid from serial no. 110125

COMPONENT TYPE		STOCK REFERENCE	CIRCUIT DIAGRAM REF.
CAPACITORS:			
Electrolytic	50 µF/500 V	CE 0901	C 7
"	16 µF/450 V	CE 6846	C 6
"	150 µF/350 V	CE 0801	C 14
"	2x100 µF/350 V	CE 2989	C 8,9,12,13
"	8 µF/320 V	CE 0800	C 2
"	2x40 µF/250 V	CE 0701	C 10,11
"	4 µF/250 V	CE 2034	C 1
"	40 µF/150 V	CE 2038	C 5
"	16 µF/ 63 V	CE 0504	C 35
"	50 µF/ 50 V	CE 0503	C 3
"	2x1000 µF/ 25 V	CE 0432	C 17
"	250 µF/ 25 V	CE 8919	C 18,19
"	24 µF/ 25 V	CE 3520	C 4
"	500 µF/ 3 V	CE 0201	C 16
"	200 µF/ 3 V	CE 8944	C 15
Ceramic	1 nF/500 V	CK 0027	C 27
"	1 pF/500 V	CK 0031	C 21,32
Paper	o.25 µF/400 V	CP 1722	C 29,30
"	o.1 µF/400 V	CP 6463	C 26,33
Polyester	22 nF/400 V	CS 0105	C 24,25
"	2 µF/250 V	CS 0028	C 34
"	o.22 µF/250 V	CS 0017	C 28
"	1 µF/250 V	CS 0025	C 31
"	o.1 µF/250 V	CS 0013	C 110-112
Polystyrol	250 pF/500 V	CT 0108	C 22
"	125 pF/125 V	CT 0104	C 23
Trimmer		CV 0013	C 41
"	6 pF	CV 0112	C 42, 43
"	3 pF	CV 0113	C 40
POTENTIOMETERS:			
Pot.m. carbon	50 kΩ lin.	PB 3509	P 4
" "	5 kΩ lin.	PG 2500	P 6
" "	50 kΩ lin.	PG 3501	P 1
" "	200 kΩ lin.	PG 4202	P 24
" "	1 MΩ log.	PP 5109	P 5
" wire-wound	100 Ω lin.	PQ 1109	P 2,3
RECTIFIERS:			
Germanium-diode	150 V	QV 0020	Q 9-12
"	OA79	QV 0078	Q 7
"	OA85	QV 0085	Q 6, 8
Silicon diode	1000 V/o.15 A	QV 0023	Q 3,4
"	50 V/o.6 A	QV 0501	Q 1,2
Zener diode	6.8 V	QV 1106	Q 5
"	13 V	QV 1316	Q 13
RESISTORS:			
Carbon film	1 W ± 10%	RK 6.3 kΩ	R 9
"	" "	RK 100 kΩ	R 8
"	1/2 W "	RK 100 Ω	R 75,76
"	" "	RK 200 Ω	R 12
"	" "	RK 800 Ω	R 16
"	" "	RK 1.25 kΩ	R 19
"	" "	RK 1.6 kΩ	R 20
"	" "	RK 20 kΩ	R 23
"	" "	RK 31.5 kΩ	R 24-26
"	" "	RK 50 kΩ	R 27,40,196
"	" "	RK 100 kΩ	R 29,77
"	" "	RK 125 kΩ	R 10,30
"	" "	RK 250 kΩ	R 35
"	" "	RK 315 kΩ	R 31,33
"	" "	RK 3.15 MΩ	R 37
"	" "	RK 10 MΩ	R 70
"	" "	RK 25 MΩ	R 39
"	" 5%	RK 86 kΩ	R 22
"	" "	RK 315 kΩ	R 32

COMPONENT TYPE		STOCK REFERENCE	CIRCUIT DIAGRAM REF.
Carbon film	1/3 W ± 10%	RK 50 Ω	R 13,78
"	" "	RK 160 Ω	R 15
"	" "	RK 1 kΩ	R 18
"	" "	RK 6.3 kΩ	R 64
"	" "	RK 7 kΩ	R 61
"	" "	RK 800 kΩ	R 14
"	" "	RK 3.5 MΩ	R 36
"	" "	RK 5 MΩ	R 195
"	" 5%	RK 56 Ω	R 11
"	" "	RK 500 Ω	R 198
"	" "	RK 800 Ω	R 197
"	" "	RK 2.5 kΩ	R 17,21
"	" + 3 - 2%	RK 63 kΩ	R 28
"	" " "	RK 112 kΩ	R 38
Wire-wound	5.6 W 6.2 kΩ	RX 0303	R 7
" "	5.5 W GL 330 Ω	RX 0300	R 2
" "	5.5 W GL 3.3 kΩ	RX 0306	R 3
" "	5 W HA 30 Ω	RX 0309	R 4
" "	3 W HA 7 kΩ	RO 0803	R 6
PRECISION RESISTORS:			
Carbon film	1/2 W ± o.5%	RK 22.2 Ω	R 41
"	" "	RK 200 Ω	R 42
"	" "	RK 2 kΩ	R 43
"	" "	RK 2.66 kΩ	R 60
"	" "	RK 8.9 kΩ	R 63
"	" "	RK 14.6 kΩ	R 47
"	" "	RK 17.6 kΩ	R 65
"	" "	RK 19.7 kΩ	R 66
"	" "	RK 20 kΩ	R 44
"	" "	RK 23.7 kΩ	R 57
"	" "	RK 31.5 kΩ	R 48
"	" "	RK 34.3 kΩ	R 68
"	" "	RK 49 kΩ	R 69
"	" "	RK 100 kΩ	R 49
"	" "	RK 200 kΩ	R 45
"	" "	RK 315 kΩ	R 50
"	" "	RK 1 MΩ	R 51
"	" "	RK 2 MΩ	R 46
TUBES etc.:			
Twin triode	ECC81/12AT7	VA 0009	V 2
"	ECC83/12AX7	VA 0012	V 1
Triode pentode	ECF82/6U8	VA 0014	V 5
Pentode	EF94 /6AU8	VA 0021	V 3,4
Stabilizer	OA2	VA 0037	V 7
"	OB2	VA 0040	V 6,8,12
Cold cathode tube	90V	VA 0072	V 14
Transistor	2N554	VB 0023	V 13
Fuse	1A	VF 0008	V 9
Dial lamp	6.3V/o.5A	VS 1271	V 10
Neon lamp		VS 8001	V 11
PRINTED CIRCUIT:			
Printed circuit		XC 0003	
"		XC 0131	
"		XC 0178	
Printed circuit	XC 0003 with comp.	2603 bl. 802	
"	XC 0131 "	2603 bl. 801	
"	XC 0178 "	2603 bl. 800	
MISCELLANEOUS:			
Power cord, Eur.		AN 0005	
Power cord, USA		AN 0006	
Moving coil meter		IM 2604	
Coaxial jack		JJ 0013	
Microphone jack		JJ 0016	

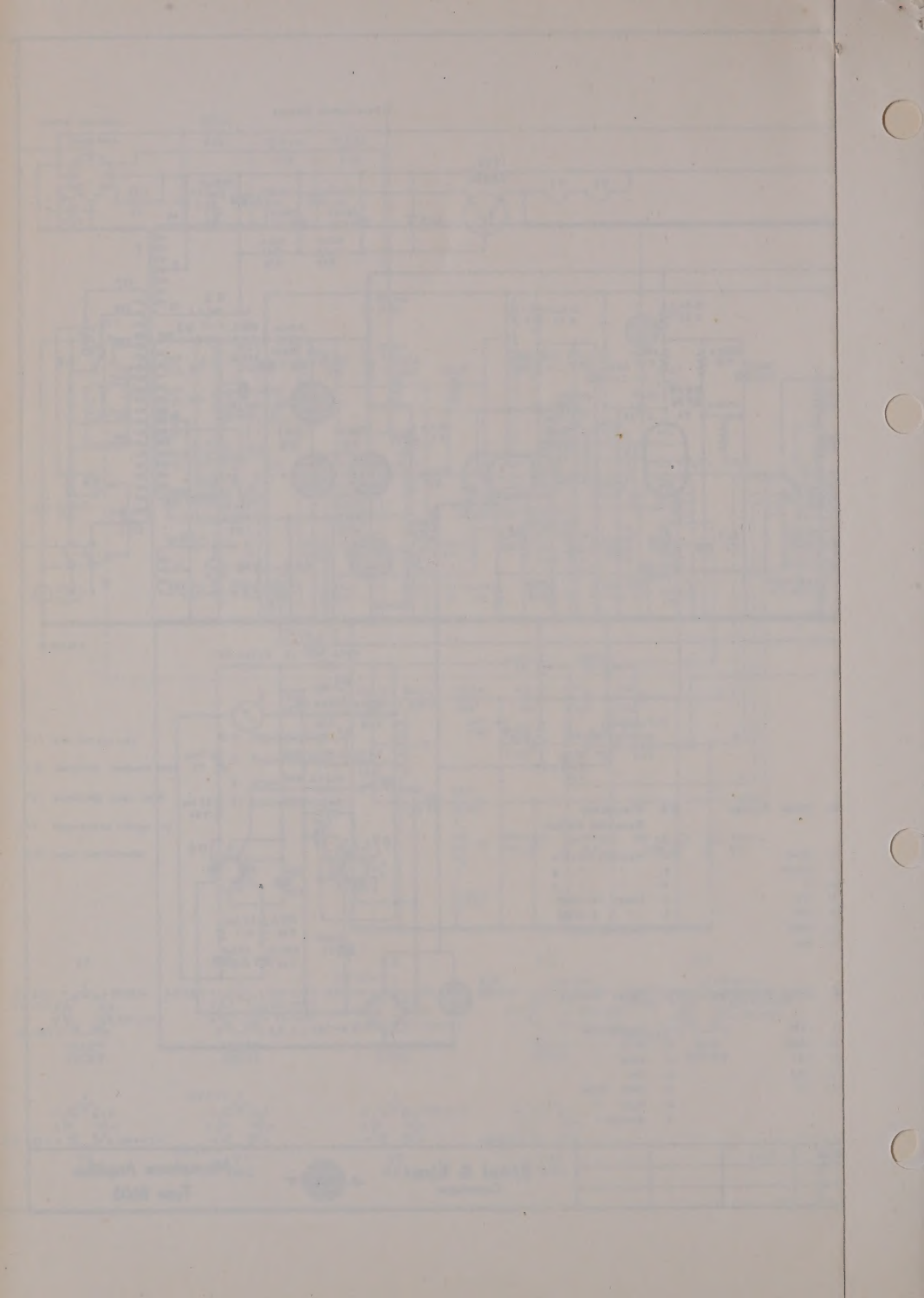
COMPONENT TYPE	STOCK REFERENCE	CIRCUIT DIAGRAM REF.
Coaxial plug	JP 0018	
Ground-jack	JT 6204	
Insulated jack	JT 8344	
Cabinet	KA 0011	
Plastic cover	KF 0027	
Power on-off switch	NN 0563	N
Power voltage selector	OA 0024	O 6
Input switch	OR 2603	O 1
Meter Range switch	OV 2110	O 2
Weighting Network switch	OT 2603	O 3
Range Multiplier switch	OT 2109	O 4
Meter switch	OS 2112	O 5
Bakelite-knob, small	SN 0814	
Bakelite-knob, large	SN 0989	
Power transformer	TN 0001	T
Phonfilter	ZS 0017	

BRÜEL & KJÆR
Nærum - Denmark

Circuit Diagram

Valid from serial no. 110125

2603.7



Position of Components

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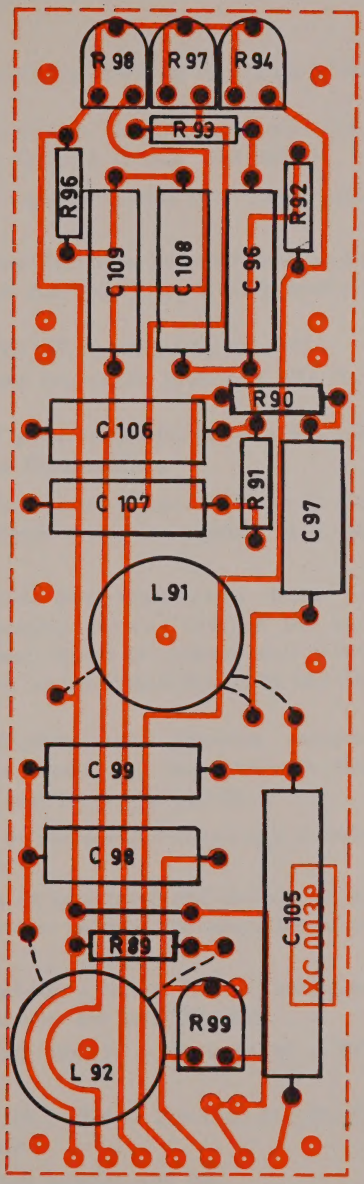


Weighting Network

Specification.

Frequency Characteristics.
"Linear": 2 c/s to 35ooo c/s to within ± o.5 db (± o.3 db in the range 5 c/s to 20ooo c/s).
"Weighting Networks": Characteristics in accordance with A.S.A. Curve C - A.S.A. Curve B (DIN 1) - A.S.A. Curve A (DIN 2) and DIN 3.

Sensitivity: Max. 100 μV full scale deflection. Min. 1ooo volts. Variable in steps of 10 db.

Amplification: Max. 100 db. Amplifier noise referred to input and max. gain: Approx. 15 μV with open input, and approx. 5 μV with short-circuited input.

Input:
1. "Direct". Input impedance 2.2 MΩ paralelled by 30 $\mu\mu$F.
2. "Input Potentiometer". Input impedance approx. 1 MΩ. To be used for relative measurements.
3. "Condenser Microphone". 7-poled socket for the B & K Condenser Microphones, Artificial Ears, and Preamplifiers.

Output: "Recorder". Output impedance smaller than 50 Ω. Output voltage corresponding to full scale meter deflection approx. 10 V. Max. available output voltage approx. 30 V.

Meter: Conveniently illuminated instrument scales. Meter perfectly safeguarded against overload. Accuracy: Approx. 2 % of full scale deflection. Scales: 0—10 and 0—31 V (linear), 0—20 db (logarithmic) as well as 3 scales calibrated in % absorption for use in connection with the Standing Wave Apparatus Type 4002.
Switch selection of two different meter damping characteristics: The characteristic standardized for sound level measurements. Heavy damping for the measurement of very low frequency signals.

Meter Rectifier: Peak—R.M.S. or arithmetic average type rectification can be selected by means of a switch.

Microphony: Careful selection of tube types and circuits as well as rubber suspension of critical components reduces the amplifier microphony to a minimum.

Polarization Voltage: The polarization voltage for the Condenser Microphone Cartridges can be adjusted between 150 and 250 volts.

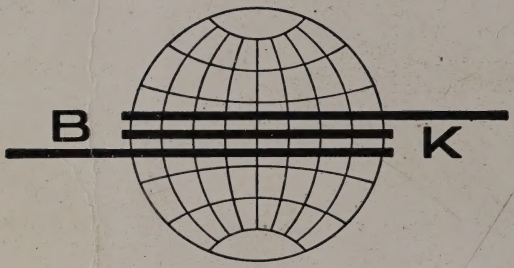
Tubes: ECC81 (12AT7) — ECC83 (12AX7) — EF94 (6AU6) — ECF82 (6U8) — EZ90 (6X4) — OA2 — OB2.

Power Supply: 115 — 127 — 150 — 220 — 240 volts AC. 40—400 c/s. Power consumption is approx. 50 watts.

Cabinet: Mahogany cabinet with handles and lid.

Accessory: 4 plugs JP 0014.

Dimensions excl. dials and knobs	Height	Width	Depth
Centimetres	40	40	20
Inches	16	16	8
Weight	20 kg	45 lbs.	



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